

THE MIDDLE EOCENE ARSHANTO FAUNA (MAMMALIA)
OF INNER MONGOLIATAO QI¹Visiting Museum Specialist
Section of Vertebrate Fossils

ABSTRACT

Review of the Eocene deposits in Inner Mongolia has shown that the classic "Arshanto Formation" forms the lower beds of the Irdin Manha Formation. Mammalian faunas from the Arshanto beds as well as from the overlying Irdin Manha beds are middle Eocene in age, roughly equivalent to the early and late Bridgerian, respectively. Two other units, formerly included in the "Arshanto Formation" are the Lower Eocene Bayan Ulan beds and the Upper Paleocene Nomogen beds, both here referred to the Nomogen Formation. Comparisons between the Inner Mongolian Arshanto fauna and the approximately time equivalent faunas of eastern and southern Asia suggest the existence of two Asiatic paleobiogeographic districts during the middle Eocene.

INTRODUCTION

From 1975 to 1981 a team of specialists on the early Tertiary from the Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, explored the Paleogene sediments in the Shara Murun region, Inner Mongolia, where the Central Asiatic Expedition of the American Museum of Natural History had made a series of investigations between 1922 and 1930. The team found approximately one hundred species of fossil mammals. Of these, a few were found by geologists mapping Inner Mongolia whereas others were recovered by the staffs of the Inner Mongolian Museum and the Institute of Vertebrate Paleontology and Paleoanthropology. Most of the discussions in this paper are based on these newly discovered fossils, although some previously collected specimens from the Arshanto fauna also are included.

The earliest report on an Asiatic middle Eocene fossil mammal (*Schlosseria magister*) was made by Matthew and Granger in 1926, but discoveries of fossil mammals of this age since that time have been rare. From the late 1950s to the present, new discoveries have been made in south Asia (Pakistan and India), central Asia (Kazakhstan), and east Asia (China) which have enhanced, considerably, our knowledge of middle Eocene mammalian faunas in Asia. The Arshanto fauna of China has a prominent position among these faunas, and the Arshantan Age has been designated as the Asiatic middle Eocene (Romer, 1966).

Study of the Arshanto has led us to the following conclusions:

1. The classic "Arshanto Formation" can be divided into three beds: the Upper Paleocene Nomogen beds, the Lower Eocene Bayan Ulan beds, and the Middle Eocene Arshanto beds. In 1975, the Nomogen mammalian fauna was discovered in Haliut and Gonghutong (Zhou and Qi, 1978) in strata at the lowest level of the classic "Arshanto Formation," but the boundary between the "Arshanto beds" and the underlying "Nomogen beds" was not clear. In 1976, another mammalian

¹ Address: Institute of Vertebrate Paleontology and Paleoanthropology, Academia Sinica, P.O. Box 643, Beijing, People's Republic of China.
Submitted 3 November 1986.

fauna (under study by Zhai), which is quite similar to but shows some differences from the Nomogen fauna, was found in Bayan Ulan above the level of the Nomogen beds. Fossil mammals also were found in the Arshanto beds in several other areas such as Arshanto Obo, Irдин Manha, Bayan Ulan, Huhe Bulak, and Ulan Bulak in 1976 and 1977. These are the main materials described in this paper, and these faunas comprise the Arshanto fauna.

2. The composition of the Arshanto fauna bears some resemblance to that of the Irдин Manha fauna. The ages of both are close, i.e., middle Eocene. Therefore, three middle Eocene mammalian faunas are recognized in the eastern part of China: the earliest, Xintai (Sintai) fauna (Zhou and Qi, 1982), the Arshanto fauna, and the latest, Irдин Manha fauna. The Arshanto and Irдин Manha faunas are quite different from the Inner Mongolian Shara Murun fauna in composition. The age of the latter is unquestionably late Eocene, on the basis of such mammals as the hyaenodontid *Pterodon*, the perissodactyl *Deperetella*, and the artiodactyl *Archaeomeryx*.

3. The age of the Arshanto fauna seems to compare most closely with that of the early middle Eocene Bridger fauna (Bridger A and B) of North America, especially on the basis of the helaletids and the brontotheriids. It must be noted, however, that some elements of the Arshanto fauna are more typically associated with older faunas (*Harpagolestes*, *Homogalax*), whereas at least *Forstercooperia* is more typically younger.

4. Based on the known fossils, the east and central Asiatic middle Eocene faunas belong to the same paleogeographic district, and both are quite different from those of the south Asiatic district. The southern fauna has some marine mammals, such as Cetacea, and some terrestrial animals, such as Proboscidea and Artiodactyla, which never or very rarely appear in the Arshanto fauna and in central Asia. Some relatives (Anthracotheriidae) of middle Eocene mammals found in south Asia were discovered in late Eocene beds in south China and Burma, but are rare in northern Asia. Therefore, southern and southeast Asia appear to belong to another paleogeographic district.

Abbreviations used in this paper are: IVPP, Institute of Vertebrate Paleontology and Paleoanthropology; AMNH, American Museum of Natural History; L, length; W, width; ant., anterior; post., posterior.

Older Chinese spelling (Wade-giles) is used in the bibliographic references through 1972, following the Bibliographies of Vertebrate Paleontology.

GEOLOGY

Field Work (Fig. 1)

Berkey and Morris (1924, p. 119) first mentioned the Arshanto beds (Formation) as follows: "At Irдин Manha, twenty miles southeast of Iren Dabasu, the Houldjin is not found, and the section exposed consists of 40 to 100 feet of grey sands, with a rich titanothera fauna, which may be late Middle Eocene or even Upper Eocene. Beneath the titanothera beds there are red clays, provisionally called Arshanto, and probably to be correlated with the barren beds above the Iren Dabasu. The Arshanto may prove to be only the lower Irдин Manha, or it may be separated from the Irдин Manha by a disconformity. The base of these beds has not been seen."

In their study of *Schlosseria magister* and *Teilhardia pretiosa*, Matthew and Granger (1926, p. 1) said, "At the base of the Irдин Manha and Shara Murun formations are red clays generally barren, to which Berkey and Morris have given

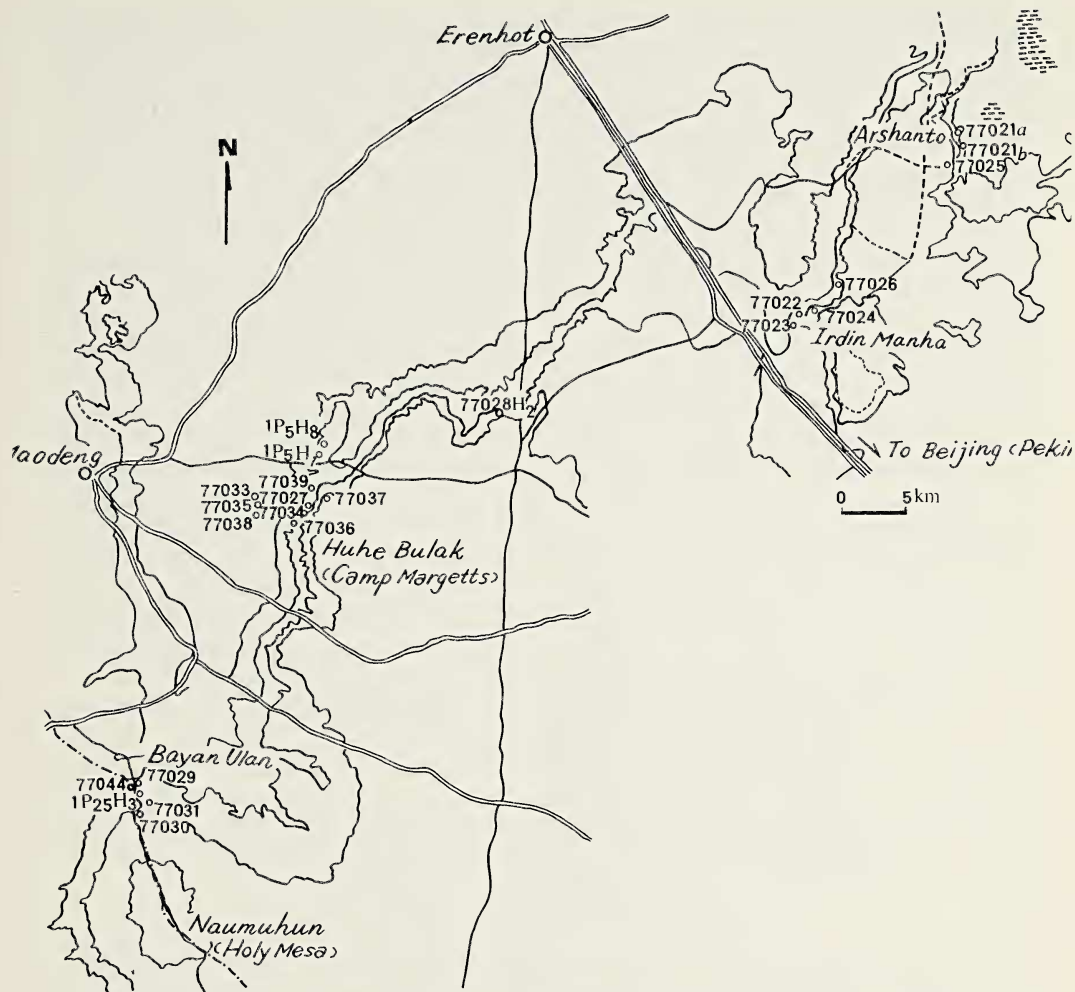


Fig. 1.—Map of Inner Mongolian Paleogene localities (“Naumuhun” = Nomogen in text).

the provisional name of Arshanto formation. The only fossils found are two remarkable little perissodactyls, apparently related to the lophiodontoid genera of the Irdin Manha and Ardyn Obo, but much more primitive. As far as the evidence goes the Arshanto may be Middle Eocene, but there is no correlation apparent with any Middle Eocene mammals of Europe or North America.”

Later, Berkey and Morris (1927, p. 207) described the Arshanto beds in detail: “The Arshanto beds are prevailing red clays and fine silts, which, on weathering, crumble into small hard chips. Much of the deposit is structureless, almost like loess. In some places a faint color-banding is seen in the red beds, but no shaly structure or marked bedding. Color-banding is held by Matthew (1915, pages 395–398) to be not inconsistent with wind deposits, and our observations tend to support his opinion. In still other places, chocolate brown beds and, more rarely, thin grey layers appear among the red, and here at least there is definite bedding. About a mile east of Irdin Manha escarpment lies another broad, un-

drained hollow (Fig. 99, page 198), part of which is called Arshanto, from which the formation is named. Here some lense-shaped beds of grey and red sandstone were found in the red clays. A limited collection of small lophiodonts was made, which has not yet been fully studied; but the preliminary examination by Matthew and Granger shows that they are quite different from the lophiodonts of the Irdin Manha beds. The base of the red beds was not seen, the only bottom known for the formation is at Iren Dabasu, where it rests upon the Cretaceous beds."

Radinsky (1964, p. 3) considered the age of the Arshanto beds early late Eocene because, "*Schlosseria* is similar enough to *Lophialetes* to indicate only a very slightly older age, possible early Late Eocene, for the Arshanto beds." Later, Radinsky (1965, p. 201) pointed out again, "*Schlosseria magister* is probably not much older than *Lophialetes expeditus* and on morphological grounds could equally well be late Middle Eocene or early Late Eocene in age." Romer (1966) took the "Arshanto Age" to designate the Asiatic middle Eocene age.

In 1975, after representative late Paleocene mammals were found by an Inner Mongolian geological mapping team, Zhou and Qi (IVPP) studied the localities and suggested on the basis of field evidence that these late Paleocene mammal-bearing beds were in the Arshanto Formation (Zhou et al., 1976). In August, 1976, paleontologists of the IVPP found fossil mammals, later named the "Bayan Ulan fauna," at Bayan Ulan, which is located on the north slope of the Nomogen Mesa. Above these Bayan Ulan beds are the Arshanto beds, which in turn are overlain by the Irdin Manha beds. The Arshanto beds yielded some middle Eocene mammals including *Gobiatherium mirificum* and *Hyrachyus cristata* new species.

In June 1977, the IVPP team discovered the incisors of *Gobiatherium mirificum*, the premolars of insectivores, and some teeth of lophialetids (field nos. 77023, 77026) at Arshanto Obo. Approximately thirty more taxa of fossil mammals were found in the Arshanto beds at Huhe Bulak and Bayan Ulan, and ten or more kinds of early Eocene fossil mammals were recovered at Bayan Ulan. Two small collections were made in these areas by the IVPP in 1978 and 1980.

Irdin Manha Formation and Arshanto Beds

Granger and Berkey (1922) proposed using "Irdin Manha Formation" for a set of grey-white sandstone beds (bearing numerous titanotheres) 25 miles south of Iren Dabasu salt lake. Thickness of the beds ranges between 40 and 100 feet. The age of the beds was considered to be Eocene-Oligocene. Later, Berkey and Morris (1924) pointed out that the age of the Irdin Manha Formation may be late middle Eocene or late Eocene. At this time they mentioned a red clay below the "titanotheres beds" and, as mentioned above, gave the provisional name, Arshanto, to the red bed.

Since 1926, when Matthew and Granger described *Schlosseria magister*, the "Arshanto fauna" was little studied until field work, mostly between 1975 and 1978, again produced many fossil mammals. These discoveries, as well as others in south Asia, central Asia, and other parts of China (Shandong and Henan provinces and Xinjiang Uighur Autonomous Region) have contributed a great deal to understanding the middle Eocene Asiatic mammalian faunas, and the Arshantan Age as an important time in geological and mammalian history.

The "Arshanto Formation" of Berkey and Morris (1927, p. 206) can be divided into two parts: the upper part, named "Arshanto beds," is here included as the lower part of the Irdin Manha Formation; the lower part of Berkey and Morris'

“Arshanto Formation” is the Nomogen Formation and contains two levels: the upper Lower Eocene Bayan Ulan beds and the lower Upper Paleocene Nomogen beds (or celestite-nodule bearing beds).

The thickness of the Irdin Manha beds is variable: at Huhe Bulak, only 5.4 m; at Bayan Ulan, 41 m; at Arshanto Obo, 10 m; and at Irdin Manha and Ulan Shireh, 12–30 m and 43 m respectively. It changes rapidly over a short distance and indicates topography at the time of deposition. In spite of the existence of an erosional surface between the Irdin Manha beds and the Arshanto beds in some places, the general characters of the two beds are quite similar. Therefore, the two beds are regarded as composing the Irdin Manha Formation. The Arshanto beds are found mainly in Sunid Yuqi (county). Their northeast extent is located near Arshanto Obo and their southwest boundary occurs at Nomogen Mesa.

Below the Irdin Manha beds in Aliusu, Urtyn Obo area, there is a set of dark red clay beds. These were previously considered Arshanto beds, but are perhaps best referred to the Nomogen Formation. They bear a pantodont, *Pastoralodon lacustris*, which is otherwise known only in the upper part of the Nomogen Formation in the Bayan Ulan fauna.

The following are abbreviated geological sections (numbers in parentheses are IVPP field numbers).

I. Arshanto Obo section (upper to lower Fig. 2)

Irdin Manha Formation

Middle Eocene Irdin Manha beds

- 4) upper part: grey-green, grey-yellow sandstone to the top having a light red medium sandstone and tobacco-yellow medium quartz sandstone with coarse quartz gravels (diameter generally less than 1 cm, the maximum 3 cm); grains rounded, but not well sorted and not well bound.
lower part: grey-green and grey-yellow medium and fine sandstone, well bound together by siliceous cement; fine silt-sandstone can often be seen in the transverse direction; locally having numerous muddy clumps, *Forstercooperia confluens* (77025). 10.13 m

————disconformity (base of channel)————

Middle Eocene Arshanto beds

- 3) dark red clay with few muddy clumps and fine silica grains, not well bound. 2.05 m
2) upper part: being covered by Quaternary plants. 13.94 m
middle part: grey-green sandstone, mainly silica grains, bound by siliceous cement.
lower part: variegated sandstone (mainly grey color; secondary dark red) with numerous muddy clumps at base bearing *Gobiathe-rium mirificum*, *Schlosseria magister*, etc. (77021). 16.88 m
1) dark red sandy clay with few muddy clumps. 1.68 m

————bottom not visible————

II. Huhe Bulak section (Fig. 3)

Irdin Manha Formation

Middle Eocene Irdin Manha beds

- 1) grey-white on surface, but grey-yellow inside, sandstone and sandy gravels with many cylinder-like calcareous masses; having grey sandy conglomerate and sandstone; gravels often black quartz, the diameter 1 cm or so, with *Andrewsarchus* (= *Paratriisodon*; McKenna, personal communication) *gigas*, etc. (77037). 5.4 m

————unconformity (=base of channel)————

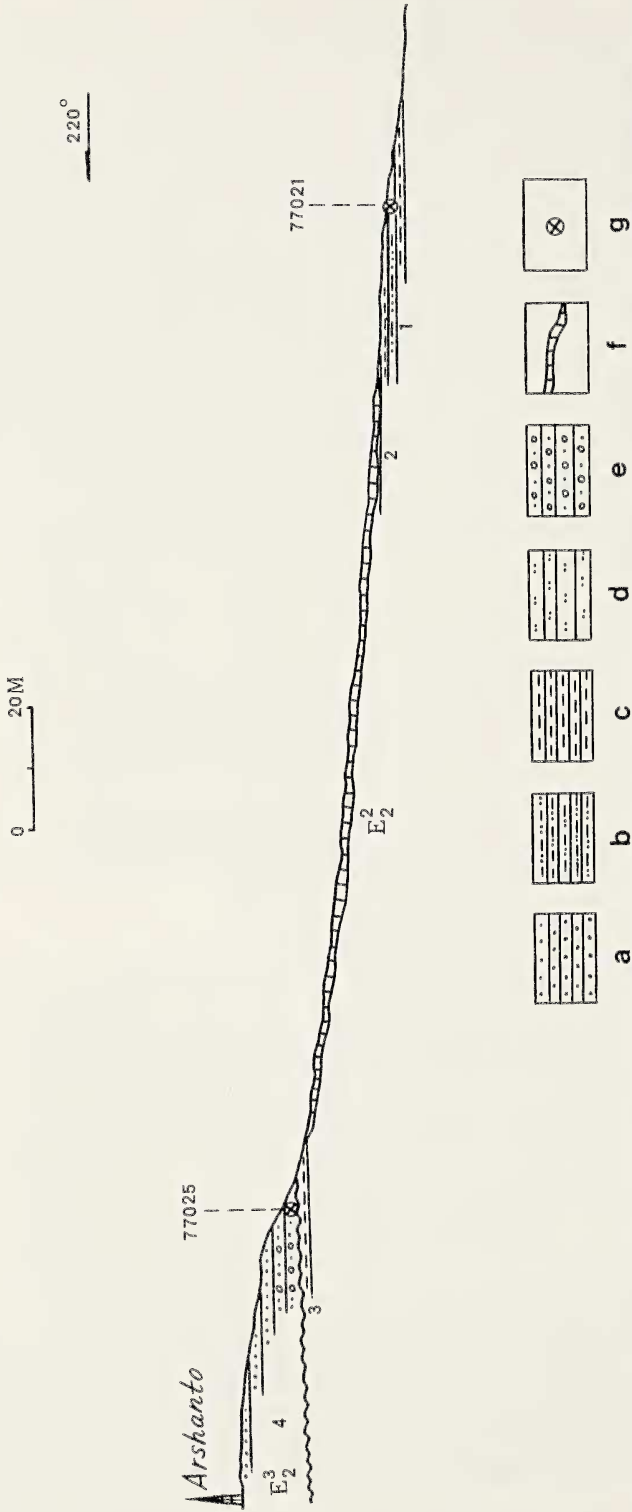


Fig. 2.—Arshanto section. (a) coarse sandstone; (b) siltstone; (c) mud stone; (d) sandstone; (e) conglomerate; (f) Quaternary cover; (g) fossil mammal locality. "E" with numerical superscript or subscript are Chinese mapping symbols that denote divisions of the Paleogene.

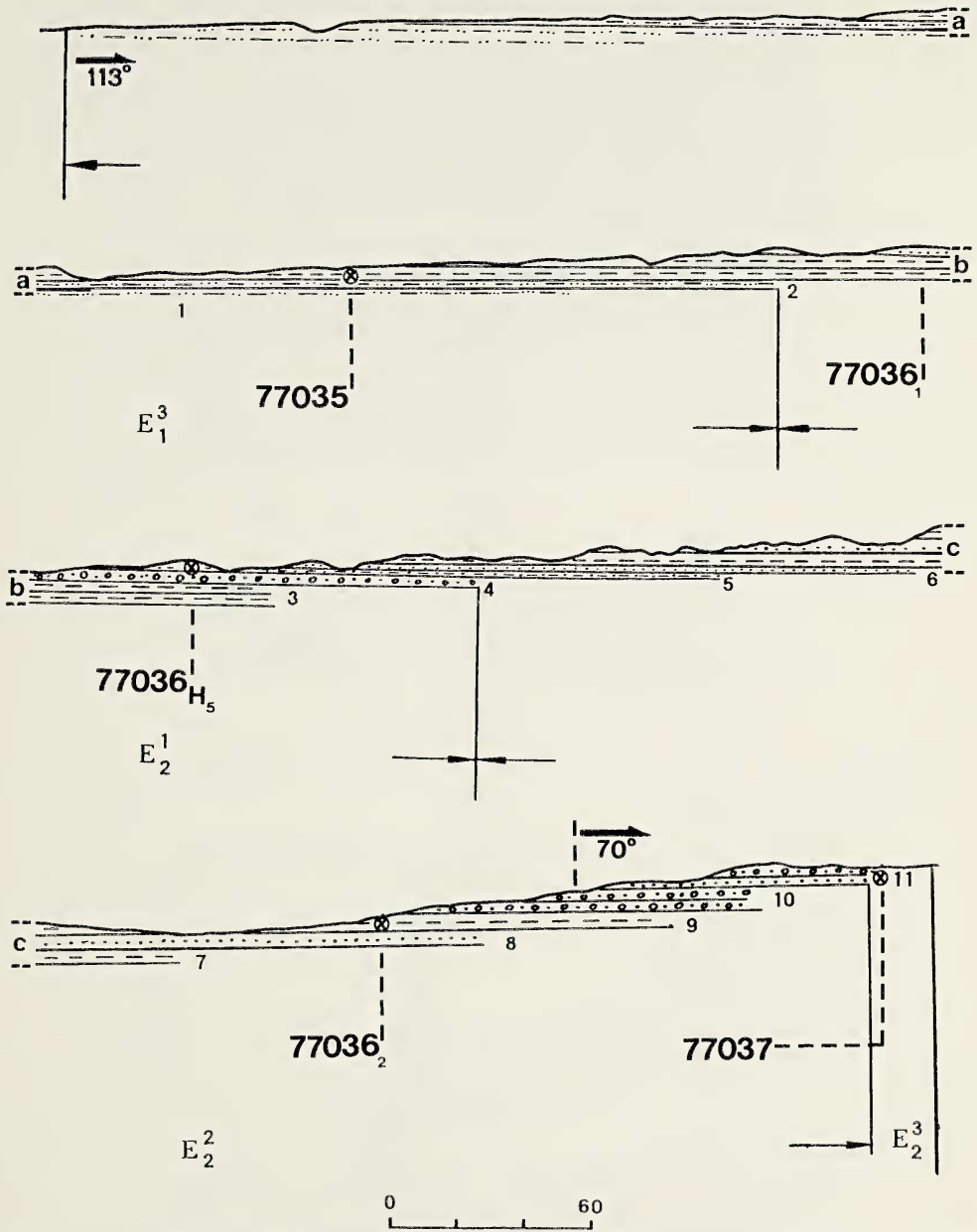


Fig. 3.—Huhe Bulak section (in 4 segments, top to bottom; complete horizontal section connects at a, b, c). See legend in Figure 2.

Middle Eocene Arshanto beds

- 10) top: dark grey-green-pink sandy clay.
- upper part: yellow-green fine sandstone.
- bottom: grey-green sandy "conglomerates" ("gravels" mainly being muddy masses and quartz, etc., diameter 0.2 cm), with *Gobia-*

- therium mirificum*, *Mesonyx obtusidens*, *Schlosseria magister*, etc.
(77036-2). 6.0 m
- 9) upper part: dark red clay with fossil mammal fragments and calcareous-nodules, diameter 1.5 cm. 4.04 m
lower part: brown clay with few manganese nodules.
- 8) red-grey muddy siltstone (white on surface), with few mammalian incisors and fragments (77036-H8). 4.85 m
- 7) brown-loess-red clay, with manganese nodules, the diameter 0.5 cm; bearing few limb bones of Dinocerata (77036-H7). 5.1 m
- 6) light loess-red siltstone. 0.3 m
- 5) brown muddy siltstone (white on surface) with few calcareous nodules, bearing *Sinosinopa sinensis* (77036-H5). 2.0 m
- 4) brown-grey sandy conglomerates (grey on surface), gravels mainly a lot of muddy masses and colorless, black, or yellow-green quartz grains, with many fossil tapirs, fragments of turtles and crocodiles. Fining upward. 3.04 m
- 3) dark red or grey-green variegated clay, with few quartz grains and calcareous nodules, bearing astragali of Dinocerata (77036-H3). Grey-green clay decreased and manganese nodules apparent up section. 6.5 m

———disconformity———

Nomogen Formation

Lower Eocene Bayan Ulan beds

- 2) brick-red sandy clay with few nodules and many bone fragments, bearing fossil tapirs, Dinocerata (*Prodinoceras* sp. = *Mongolotherium*; McKenna, personal communication) (77035). 2.76 m
- 1) loess-red and grey-green clay with many calcareous nodules between 5–10 cm diameter. 3.0 m

———base not visible———

III. Bayan Ulan sections (after material of the Inner Mongolian mapping team; Fig. 4)

Ulan Gochu Formation

Oligocene

- 17) loose coarse sandstone with gravels with fragments of cf. *Indri-cotherium* sp. (1P₂₅H₁₉). 6.6 m
- 16) variegated clay. 2.6 m
- 15) grey-white medium feldspar-quartz bearing sandstone with *Teleolophus magnus*. 0.5 m
- 14) brown-red clay. 1.8 m
- 13) grey-white silt-sandstone. 3.3 m
- 12) grey-white medium feldspar-quartz bearing sandstone. 4.8 m
- 11) light brown-red clay. 1.6 m
- 10) grey-white coarse sandstone with gravels. 0.3 m

———disconformity———

Irdin Manha Formation

Middle Eocene Irdin Manha beds

- 9) brown-red clay with *Gobiohyus* sp., ?*Harpagolestes* sp. and Mesonychidae indet. (1P₂₅H₁₁). 27.5 m
- 8) loose manganese sandy conglomerates and loose medium-coarse sandstone. Upper part: grey-white, light yellow medium feldspar-quartz bearing sandstone with *Teleolophus* sp., *Microtitan mongoliensis*, and *Lophialetes* sp. 6.9 m
- 7) variegated silty clay, with *Microtitan mongoliensis*, *Lophialetes* sp., *Eudinoceras* sp., and *Rhodopagus* sp. (1P₂₅H₇). 6.7 m

———disconformity———

Middle Eocene Arshanto beds

- 6) brown-red clay with grey-green clay, with *Rhodopagus* sp., and *Lophialetes* sp. 10 m

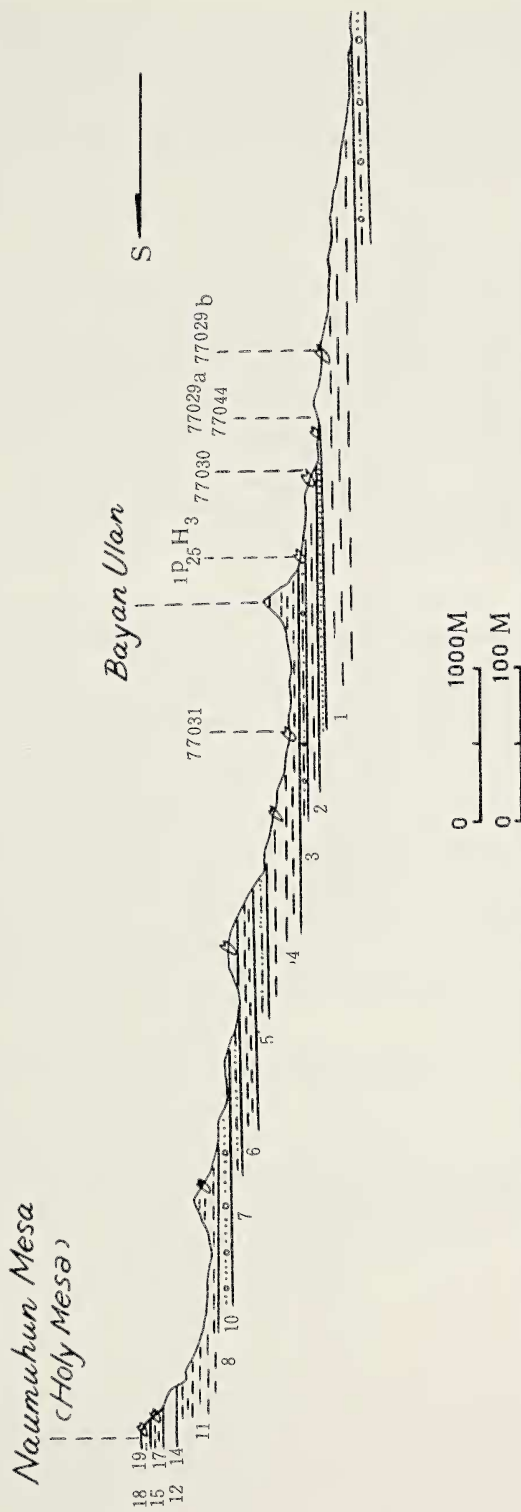


Fig. 4.—Bayan Ulan section (Holy Mesa area). See legend in Figure 2. Upper scale, horizontal; lower scale, vertical.

- 5) grey-green silty clay. 2.9 m
 4) brown-red clay with grey-green siltstone and grey-green clay, bearing ?*Mongolonyx prominentis*, *Hyrachyus cristata*, *Breviodon minutus*, *Pantolambdodon* sp., and *Lophialetes* sp. 25 m
 3) gravel-bearing brown-red clay with green clay and siltstone, the bottom is brown sandy conglomerates, bearing *Gobiatherium monolobatum* (1P₂₅H₃). 4 m

——disconformity——

Nomogen Formation

Lower Eocene Bayan Ulan beds

- 2) variegated clays with *Prionessus lucifer*, *Mimotona borealis*, *Pseudictops lophiodon*, *Pachyaena* sp., *Plagiocristodon serratus* (milk teeth of *Dissacus*, McKenna, personal communication), *Pastoralodon lacustris*, *Prodinoceras* (= *Mongolotherium*; McKenna, personal communication) *efremovi*, *Prodinoceras* (= *Mongolotherium*) sp., *Pyrodon* sp., *Palaeostylops iturus*, *Palaeostylops macrodon*, *Mongolotherium* sp., and ?*Lambdotherium* sp. 6.5 m
 1) brown-red sandy-silty sandstone, grey-green silty clay appears in the top. Bottom: grey-white silty clay with gravels and red muddy sandstone with gravels, bearing *Pastoralodon lacustris*, *Prionessus lucifer*, *Sarcodon pygmyaeus*, *Palaeostylops iturus*, and *Pantolambdodontidae* (new genus and species), etc.

——bottom not visible——

FOSSIL MAMMALS FROM ABOVE AND BELOW THE ARSHANTO BEDS

I. The Overlying Irdin Manha Beds

The Irdin Manha fauna has been collected from at least ten sites, of which four are major: the Irdin Manha escarpment, Ulan Shireh, Aliusu, and Camp Margetts.

1. Irdin Manha escarpment. This site is located 40 km south of Iren Dabasu salt lake on the southwest edge of Suji Mesa. This is the type area of the Irdin Manha Formation and has been called by various authors "Irdin Manha Formation," "Irdin Manha beds," "Irdin Manha area," and "near Irdin Manha." The thickness of the type Irdin Manha beds is 41 m and the fossil quarry (a titanotherium site excavated by Russian paleontologists) is not far above the Arshanto beds. Appendix 1 lists the fauna from this site.

2. Ulan Shireh. The fossil quarry is located 10 km northeast of Tukhum Lamasary (Siziwangqi). No fossil mammals were discovered in other beds at this site.

3. Aliusu. This fossil quarry was found in 1975 by the staff of the Inner Mongolian mapping team and the author. It is located in the Urtyn Obo area. These beds appear to be correlatives of the type Irdin Manha beds, and preserve the following fossil mammals:

Rodentia

Adenimus sp.

Creodonta

Propterodon sp.

Pantodonta

Eudinoceras mongoliensis

Pantolambdodon inermis

Acreodi

?*Harpagolestes orientalis*

Perissodactyla

Protitan grangeri
Microtitan mongoliensis
Microtitan sp.
Lophialetes expeditus
Breviodon minutus
Breviodon sp.
Teleolophus medius
Teleolophus sp.
Forstercooperia confluens
 Artiodactyla
Gobiohyus orientalis
Dichobunid sp.

4. Camp Margetts. Camp Margetts was located somewhere in the Ulan Bulak-Huhe Bulak escarpment, some kilometers to the west of the Irdin Manha escarpment. The AMNH Central Asiatic Expedition collected a few fossil mammals from two beds called "Houldjin beds" and the underlying "Irdin Manha beds" in this area. The discovery in 1978 of *Lophialetes expeditus* in the "Houldjin gravels" here proved that they represent a lateral facies of the type Irdin Manha beds, and should be considered part of the Irdin Manha Formation. The underlying "Irdin Manha beds" at Camp Margetts are probably equivalent to the Arshanto beds.

On the other hand, some AMNH fossils are labeled as coming from "7 miles (about 10 km) southwest of Camp Margetts," or "10 miles (17 km) west of Camp Margetts," or "5 miles (8 km) west of Camp Margetts." Among these sites, the "west" area may be the Bayan Ulan area. These sites cannot be correlated directly with the strata in the Camp Margetts area. However, we may guess the provenance of some fossil mammals by referring to those preserved in the type Irdin Manha and type Arshanto beds. Cf. *Hyrachyus* and *Helaletes* sp., for example, probably came from the Arshanto level, and *Forstercooperia confluens*, *Mongolonyx dolichognathus*, and *Litolophus (Grangeria) gobiensis* from Irdin Manha levels.

The fossil mammals from known localities in the Camp Margetts area are listed below (excluding the new mammals reported in this paper):

A. Irdin Manha level ("Houldjin beds")

Pantodonta
Hypocoryphodon thomsoni Osborn, 1932
 Condylarthra
Andrewsarchus (=Paratriisodon) gigas (Qi, 1980)
 Perissodactyla
Lophialetes expeditus Radinsky, 1965
Brontotheriidae indet. Qi, 1980

B. Arshanto beds

Rodentia
 ?Paramyid sp. Dawson, 1964
Tamquammys wilsoni Dawson, Li and Qi, 1984
Advenimus burkei Dawson, 1964
 Dinocerata
Gobiotherium mirificum Osborn, 1932
 Perissodactyla
Schlosseria sp. cf. *Schlosseria magister* Radinsky, 1965
Helaletes fissus Matthew and Granger, 1925
Helaletes fissus? Radinsky, 1965
Metatelmatherium cristatum Granger and Gregory, 1943
Protitan minor Granger and Gregory, 1943

II. The Underlying Bayan Ulan Beds

The following mammalian fauna of early Eocene age is found in these beds (Zhai, under study):

- Multituberculata
 - Prionessus lucifer*
- Anagalida
 - Mimotona borealis*
 - Pseudictops lophiodon*
- Notoungulata
 - Palaeostylops iturus*
 - P. macrodon*
- Acreodi
 - Pachyaena* sp.
 - Dissacus* (= *Plagiocristodon*) *serratus*
- Pantodonta
 - Pastoralodon lacustris*
- Dinocerata
 - Prodinoceras* (= *Mongolotherium*) *efremovi*
 - Prodinoceras* (= *Pyrodon*) sp.
- Perissodactyla
 - ?*Lambdaotherium* sp.

ASIATIC MIDDLE EOCENE MAMMALS

Asiatic middle Eocene mammals have been found in east Asia (China: Inner Mongolia, Shandong, and Henan; Mongolian People's Republic), central Asia (China: Xinjiang, and U.S.S.R.: Kazakh region), and south Asia (Pakistan and India). Areas yielding important discoveries are:

1. Central part of Shandong Province. After the original report (Zdansky, 1930), Young and Bein (1935) and Chow (1957, 1963) added more middle Eocene mammals. Zhou and Qi (1982) summarized the Shandong Eocene mammals, and Qi and Meng (1983) reported two other species of perissodactyls collected in Wufu County. Appendix 2 lists the middle Eocene mammals from central Shandong.

2. Henan Province. Zhou et al. (1975, p. 179) concluded of the Lushi fauna, "It is typically a southern extension of the Irдин Manha fauna (type locality), but contains some interesting forms which are not known in the Irдин Manha" (Appendix 1).

Gao (1976) divided the Paleogene in the Wucheng and Xichuan Basins, Henan, into four formations (lower to upper): 1) Yuhuangding Formation; 2) Dacangfang Formation; 3) Hetaoyuan Formation; and 4) Shangsi Formation. Only a coryphodontid and a dinoceratan were found in the Yuhuangding Formation, the age of which is considered to be, "not later than Middle Eocene." Fossil mammals found in the Dacangfang Formation are:

- Rodentia
 - Sciuravus* sp.
- Carnivora
 - Miacis* sp. aff. *M. invictus*
- Creodonta
 - ?*Sinopa* sp.
 - ?*Tritemnodon* sp.
- Acreodi
 - ?*Andrewsarchus* sp.
- Perissodactyla
 - Sianodon* sp.

Teleolophus sp. cf. *T. medius*
Deperetella new species
Breviodon sp. cf. *B. minutus*
Lophialetes sp.
Colodon sp.
 ?*Protitan* sp.
Tillodontia
Chungchienia sichuanica

Gao (1976) concluded that [translated from Chinese], "The age of the majority of the fossil mammals collected from Hetaoyuan Formation should be the same as the Irdin Manha fauna found in Inner Mongolia."

Accordingly, the Yuhuangding Formation may be tentatively correlated with the Guanzhuang Formation, the Dacangfang Formation with the Arshanto beds, and the Hetaoyuan Formation with the Irdin Manha beds.

3. U.S.S.R. Since the early 1960s, middle Eocene mammals have been reported from the Zaysan (Zaisan) Basin, Kazakh region (Appendix 3).

4. Pakistan and India. Following Pilgrim's description (1940) of middle Eocene mammals from North-west India, Dehm and Oettingen-Spielberg (1958) described the middle Eocene Ganda Kas fauna from Pakistan. Later, several studies reported on middle Eocene mammals from India and Pakistan (West, 1980, and Appendix 4).

Additional collections of possibly middle Eocene mammals have been made in southern provinces of China, including Yunnan, Guangzi, Hubei, and Jiangxi.

MIDDLE EOCENE FAUNAL ZONES IN EAST ASIA

There are three middle Eocene mammalian faunal zones in east Asia. From oldest to youngest, there are: 1) Guanzhuang faunal zone (Shandong Province); 2) Arshanto faunal zone (Inner Mongolia); and 3) Irdin Manha faunal zone.

Hyrachyus modestus collected from the Guanzhuang Formation also occurs in Bridger B beds in North America. The tillodont, *Kuanchuanianus shantunensis* (Chow, 1963), from Shandong resembles *Trogosus* and *Tillodon* (both lower Bridger; Stucky and Krishtalka, 1983). Accordingly, the age of the Guanzhuang and lower Bridger faunas may be comparable.

In the Arshanto fauna, *Hyrachyus* sp. cf. *H. eximius* is close to *Hyrachyus eximius* from the Bridger C and D. Other similar tapiroids, such as helaletids, occur in both faunas. This indicates that the Arshanto fauna is younger than the Guanzhuang fauna and closer in age to the upper Bridger fauna. *Homogalax*, a typical North American Greybullian tapir, survives as a relict in the middle Eocene Arshanto fauna of Asia.

Although the Guanzhuang and Arshanto faunas have certain endemic taxa, their composition suggests that faunal exchange took place during the early and late Bridgerian between east Asia and North America.

The Arshanto and the Irdin Manha faunas appear to be closely related. A main characteristic of the Arshanto fauna is the dominance of a variety of perissodactyls and the absence of artiodactyls. Of the 43 species in the Arshanto fauna, about 23 (53%) are perissodactyls. Perissodactyls still dominate the Irdin Manha fauna, but several new families appear: Leporidae, Oxyaenidae, Hyaenodontidae, Miacidae, and Amynodontidae(?).

The following species occur in both faunas: *Breviodon minutus*, ?*Forstercooperia grandis* and *Pantolambdodon fortis*. Genera in common are: *Hapalodectes*, *Mesonyx*, *Helaletes*, *Teleolophus*, *Protitan*, and *Telmatherium*. Importantly, phylo-

genetic relationships are evident between several taxa in the two faunas such as: *Schlosseria magister* and *Lophialetes expeditus*; *Helaletes medius* and *H. mongoliensis*; *Telmatherium cristatum* and *T. parvum*; *Protitan minor* and *P. robustus*; and *Metacoryphodon*, *Eudinoceras*, and *Hypercoryphodon*.

The similarities between the Arshanto and Irdin Manha faunas are in contrast to the differences between the latter and the Shara Murun fauna. There are only three shared genera (*Shamolagus*, *Rhodopagus?* and *Triplopus?*) in the Irdin Manha and Shara Murun faunas, and no shared species. There are some phylogenetic relationships between several species such as *Teleolophus medius* and *Deperetella cristata*, and *Forstercooperia confluens* and *Juxia sharamurunensis*, as well as within the Rodentia and Lagomorpha. But in the Shara Murun fauna, brontotheres and artiodactyls (mainly *Archaeomeryx optatus*) are dominant, whereas they are absent from the Irdin Manha fauna. The appearance of the Family Anthracotheriidae in the Shara Murun fauna marks the beginning of the late Eocene in China.

East Asia and central Asia were in the same paleobiogeographic district (North Paleobiogeographic District) during the middle Eocene. The central Asian middle Eocene mammalian faunas occur mainly in the Kazakh and Kirgizia regions, U.S.S.R., and in Xinjiang, China, but correlating these faunas is difficult. The fauna from Xinjiang appears to be equivalent to the Irdin Manha fauna. The central Asian faunas are generally similar in composition to those of east Asia, and may represent extensions of the eastern Arshanto and Irdin Manha faunas, although not of the Guanzhuang fauna. Middle Eocene genera common to central and eastern Asia are: *Lophialetes*, *Helaletes*, *Teleolophus*, *Forstercooperia*, *Triplopus*, *Pataecops*, *Eudinoceras*, and *Tamquammys*.

South Asia was another paleobiogeographic district (South Paleobiogeographic District) in the middle Eocene. At present, the Qinghai-Tibetan plateau stands between east-central Asia and south Asia. During the middle Eocene, at least during a large part of that time, Tethys lay, in part, between the two. Recent discoveries do not support the assumption that south Asia and east-central Asia were in the same paleobiogeographic district. Unquestionably there were some links between the two areas. Some genera such as *Schlosseria*, *Teleolophus*, *Forstercooperia*, and *Tamquammys* were shared between south Asia and east Asia, but there are considerable differences at the specific level between the two regions. The appearance of *Gobiohyus orientalis* in the two areas indicates that the age of the south Asian faunas is, in part, equivalent to that of the Irdin Manha fauna and that during the time of the Irdin Manha fauna the eastern part of the Tethys Sea had already closed, allowing exchange of some mammals.

Finally, Sahni et al. (1981, p. 693) pointed out that the middle Eocene south Asian fauna "includes perissodactyls and rodents, most of them being endemic at the generic level, showing strong and indubitable affinities to the Eocene faunas of Northern Asia, Mongolia and Kazakhstan. The diversity among these groups and the endemism of the taxa strongly suggest an Early Eocene immigration from the North." A recent study of the origin of the proboscideans (Domning et al., 1986) suggests, however, another route for faunal migration between south-east Asia and south Asia, namely, a South China-Burma-Indo-Pakistan route.

SYSTEMATIC PALEONTOLOGY OF THE ARSHANTO FAUNA

The discoveries of the Arshanto fauna are centered in the Shara Murun area, i.e., 110°30' to 112°30' E; 43°00' to 43°40' N. Most of the fossil mammal sites are located in Sunid Yuqi (county) of Ulan Chabu Mong, Inner Mongolia.

Grandorder Insectivora Illiger, 1811
 Order Soricomorpha Gregory, 1910
 Superfamily Palaeoryctoidea Winge, 1917
 Family Micropternodontidae Stirton and Rensberger, 1964
Sinosinopa, new genus

Type species.—*Sinosinopa sinensis*, new genus, new species.

Included species.—Type and only species.

Diagnosis.—Retains M_3^3 unlike *Prosarcodon* and *Sarcodon*; P_4 more elongate and M^{1-2} with larger hypocone shelf.

Sinosinopa sinensis, new species

(Fig. 5; Table 1)

Holotype.—V5677, incomplete skull and mandible, with left P^1 – M^3 , right C^1 – P^4 (M^{1-2} broken), and left M_{2-3} (field no. 77036-H₅).

Diagnosis.—Dental formula $?/?$, $1/?$, $4/?$, $3/3$; large in size; diastema very short; nasal bone elongate; post-metacrista fairly long; hypocone shelf (talon basin) very wide; M^3 with two paraconules; trigonids and talonids well developed; trigonid of M_3 very long; metaconulid fairly prominent.

Description.—Skull: ascending ramus of premaxilla present; maxilla relatively high and long; nasal bone very elongate, its posterior edge above M^1 ; frontal bone relatively broad; orbit large; infraorbital foramen fairly small; zygoma not deep (posterior part broken); palatine part of maxilla very long; and foramen incisivum fairly large.

Upper teeth. C^1 : relatively robust; transverse section oval; postcanine diastema fairly short. P^1 : smallest in size; compressed anteroposteriorly; one main cusp, anterior edge of cusp relatively steep. P^2 : larger in size; anterior edge of main cusp less steep than that of P^1 , posterior edge also gentle; cuspule on posterior edge of tooth, but not clear. P^3 : crown view triangular; paracone and protocone clear; small cuspule (parastyle) on anterior edge of tooth; another larger cuspule (metastyle) on posterior edge. P^4 (paracone and metacone broken): becoming molariform; protocone prominent; pre-protocrista and post-protocrista clear, forming a narrow trigon basin; hypocone relatively prominent; hypocone shelf very narrow; parastyle small, relatively prominent; metastyle prominent, but not extending very far posteriorly. M^1 : protocone prominent; pre-protocrista and post-protocrista not prominent; pre-paraconule crista relatively clear; post-paraconule crista not clear; trigon basin narrow; parastyle and metastyle (crowns broken) forming a “V”-shaped ectoflexus (sharp at bottom of “V,” and anterior wing of “V” longer than posterior wing); a small cingulum in front of paraconule; trigon basin wide; a prominent hypocone and another small cusp on postero-lingual edge of trigon basin. M^2 : post-metacone crista (broken) probably fairly elongate; protocone prominent; trigon basin narrow; paraconule larger than metaconule; pre-paraconule crista less clear than that of M^1 ; stylar shelf narrow; parastyle cone-like; metastyle relatively elongate; ectoflexus opening largely; small segment of cingulum anterior to paraconule; trigon basin wide; prominent hypocone and another cuspule at postero-lingual edge of trigon basin. M^3 : protocone prominent; pre-protocrista and post-protocrista clear; with two paraconules, one on lingual side smaller than other; trigon basin wide; paracone close to metacone; paracone high; no metastyle, cingulum, and hypocone.

Mandible: horizontal ramus slender; anterior edge of ascending ramus relatively steep; anterior edge of masseteric fossa at rear of M_3 .

Lower cheek teeth. P_4 (main cusp broken): anterior and posterior cuspules clear; section of crest in posterior part of tooth. M_1 : (only two roots left). M_2 : trigonid and talonid clear, length almost same; protoconid-paraconid-metaconid forming distinct trigonid; carnassial notch between protoconid and paraconid stronger than that between protoconid and metaconid; positions of hypoconid, entoconid, and hypoconulid somewhat posterior; cristid obliqua between hypoconid and protoconid relatively strong; small cingulum on antero-labial side of paraconid. M_3 : talonid narrow and elongate, hypoconulid very prominent; distance between hypoconid and entoconid, and hypoconulid longer than on M_2 ; cristid obliqua stronger.

Discussion.—When Matthew and Granger (1925a) described the genus *Sarcodon*, only M^1 was known. Its systematic position was uncertain until Szalay and McKenna (1971, pp. 286–293) recognized the lower teeth of *Opisthopsalis vetus*

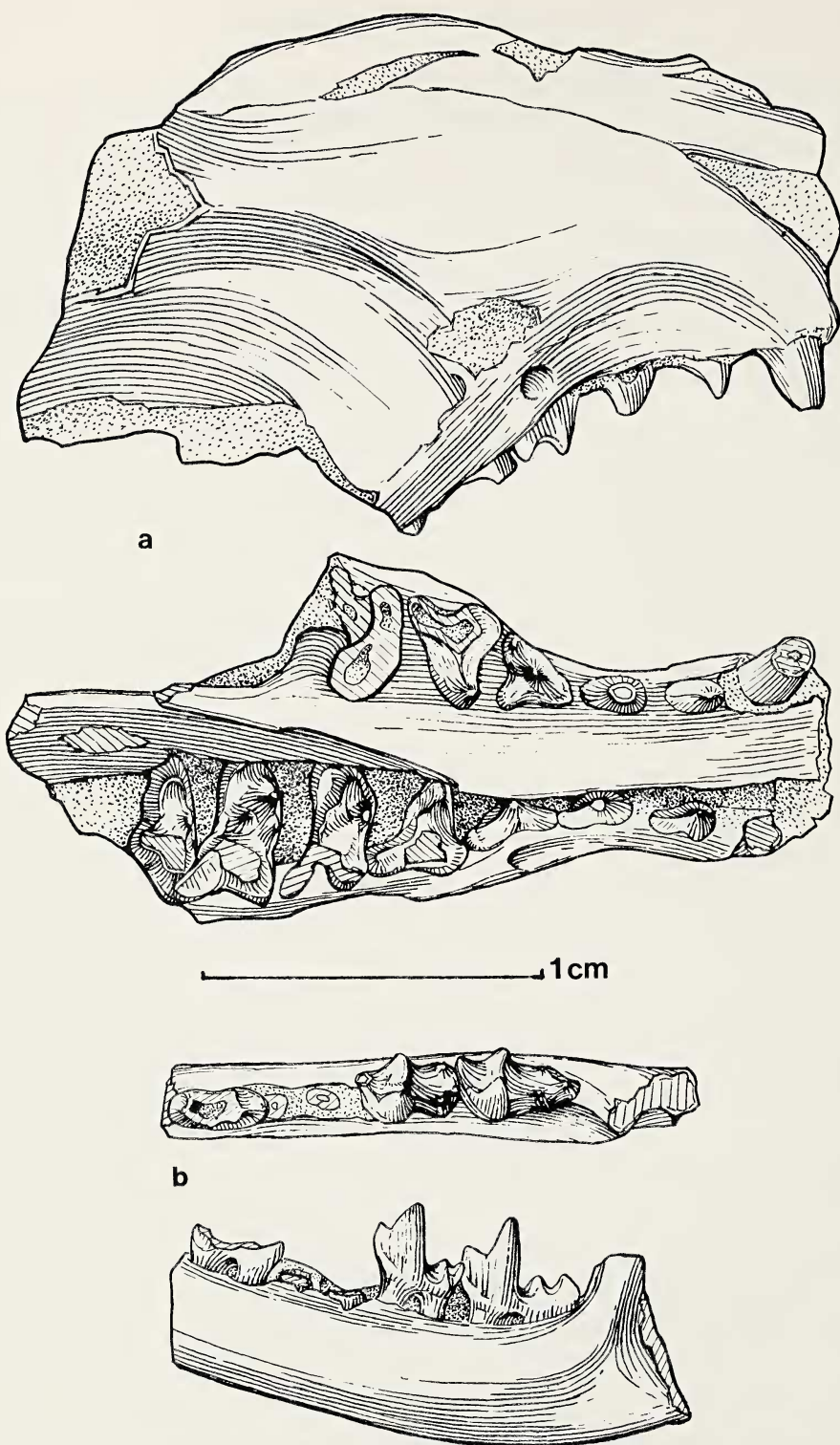


Fig. 5.—*Sinosinopa sinensis* new genus, new species. Holotype, V5677. (a) skull, lateral and palatal views. (b) mandible, crown and lateral views.

Table 1.—Measurements (mm) of *Sinosinopa sinensis* (V5677).

	L	W
C ¹	1.8	1.7
P ¹	1.8	1.0
P ²	2.2	1.1
P ³	2.5	2.0
P ⁴	3.2	2.8
M ¹	2.7	4.1
M ²	3.0	4.4
M ³	1.5	3.9
P ¹⁻⁴	10.3	
M ¹⁻³	7.3	
P ¹ -M ³	16.9	
C ¹ -M ³	20.9	
P ₃	3.0	1.4
P ₄	2.3	
M ₂	3.3	1.9
M ₂ trigonid	1.7	1.9
M ₂ talonid	1.6	1.7
M ₃	3.7	1.9
M ₃ trigonid	1.8	1.9
M ₃ talonid	1.9	1.4
Mandibular depth below P ₄	3.4	

Matthew, Granger and Simpson, 1929, as referable to *Sarcodon*, and considered similarities of upper dentitions of *Sarcodon* and *Micropternodus* a result of convergence.

When McKenna et al. (1984) described *Prosarcodon lonanensis*, they made detailed comparisons between *Prosarcodon*, *Sarcodon*, and *Sinosinopa*. *Sinosinopa* differs from *Prosarcodon* and *Sarcodon* in that "it retains all three molars. In *Sinosinopa* both M¹ and M² possess a hypocone that juts strongly posterolingual; in *Prosarcodon* M², the last molar, possesses a narrow cingulum-like hypocone. P₄ of *Sinosinopa* is more elongate than in either *Sarcodon* and *Prosarcodon*." They concluded, "That *Prosarcodon*, *Sarcodon*, and *Sinosinopa* are lipotyphlan insectivores is suggested by the presence of a piriform fenestra in *Prosarcodon*."

There is a well developed hypocone shelf on M¹ of the type specimen of *Sarcodon* (AMNH 20427). *Sarcodon* or *Prosarcodon* could not be ancestral to *Sinosinopa* because *Sinosinopa* has M³. Apparently two different lineages of these early insectivores existed in Asia: 1) *Prosarcodon* and *Sarcodon*, which lost M³ and developed the hypocone shelf; 2) *Sinosinopa*, which kept M³ but "is more specialized in having jutting hypocones on several upper molars" (McKenna et al., 1984, p. 13).

Order Rodentia Bowdich, 1821
 Family Paramyidae Miller and Gidley, 1918
 Subfamily Reithroparamyinae Wood, 1962
Asiomys, new genus

Type species.—*Asiomys dawsoni*, new genus, new species; only known species.
Diagnosis.—Differs from *Reithroparamys* in having a prominent protoloph on

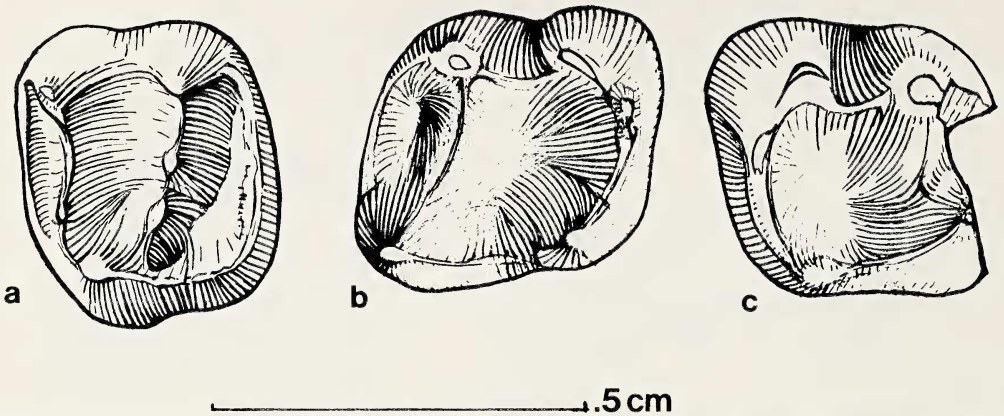


Fig. 6.—*Asiomys dawsoni* new genus, new species. (a) holotype, V5684, M¹; (b) V5685, M₁; (c) V5686, M₂.

M¹, a closed trigonid basin on M₁; differs from *Franimys* in having closely approximated paracone and metacone on the upper molars; unlike *Rapamys* M₁ posterior cingulid not close to entoconid.

Asiomys dawsoni, new species
(Fig. 6)

Holotype.—V5684, a right M¹ (field no. 77026).

Referred specimens.—V5685, right M₁ (field no. 77027); V5686, left M₂, and incisor (field no. 77028).

Localities.—Irdin Manha area (type), Huhe Bulak, and Daatein Obo.

Diagnosis.—Medium-sized reithroparamyine; upper and lower cheek teeth nearly square in crown view; double metaconules on upper molar; protocone-metaconules-metacone forming a crest; ectolophid developed on lower molar.

Description.—M¹ (L, 3.8; W, 4.6): protocone prominent, paracone and metacone conical, close together; paraconule near protocone, paracone-paraconule-protocone forming paraloph; double metaconules, that near protocone larger in size, the other not prominent; metaloph connected with protocone directly, not with hypocone; mesostyle relatively apparent; hypocone prominent; hypocone shelf relatively broad; posterior cingulum low and wide but not enclosing metacone; anterior cingulum narrow and short, ended at the paraconule lingually; straight valley on lingual wall between protocone and hypocone but not reaching base. M₁ (L, 4.0; W, 3.9): double crests from protoconid forming an anterior-posterior short, closed trigonid basin; ectolophid developed but not closed to labial side and connecting protoconid and hypoconid; hypoconid relatively prominent, connecting with posterior cingulum; two small points on posterior cingulum; entoconid isolated. M₂ (W, 4.0): similar to M₁, but larger in size and protolophid II shorter, so trigonid basin opens posteriorly.

Discussion.—The discovery of middle Eocene *Asiomys dawsoni* is the first record of the Reithroparamyinae in Asia. This subfamily includes three other genera, *Reithroparamys*, *Franimys*, and *Rapamys*, all from North America (Wood, 1962).

In size, *Asiomys* is close to both paramyines and reithroparamyines. The upper molars of the paramyines have only one metaconule, while the reithroparamyines have double metaconules. The earlier members of the Reithroparamyinae, such as *Reithroparamys*, have double metaconules on the upper molars, one larger and another smaller. In addition to this similarity, the referred lower teeth from Inner Mongolia resemble reithroparamyines in features such as medium size and entoconid completely separate from posterior cingulum.

Table 2.—Measurements (mm) of *Tamquammys wilsoni*.

	V5678		V5679			V5680		
	L	W	L	W trigonid	W talonid	L	W trigonid	W talonid
dP ³	0.7	0.9						
dP ⁴	1.2	1.7						
P ⁴	1.3	1.7						
M ¹	1.4	1.8						
M ²	1.5							
Diastema	4.0							
P ₄			1.5	1.1	0.9			
M ₁			1.5	1.3	1.5	1.3	1.2	1.4
M ₂			1.7	1.5	1.6	1.7	1.4	1.5
M ₃			1.9	1.6	1.5	1.8	1.5	1.4
P ₄ –M ₃			6.7					
M ₁ –M ₃			5.1			4.5		

M¹ of the Inner Mongolian species differs from that of *Reithroparamys* in several points. The protoloph of the Inner Mongolian specimen is more prominent, whereas it is indistinct, if present at all, in *Reithroparamys*. In *Reithroparamys delicatissimus*, for instance, the end of the protoloph is anterior to the protocone, not connected with it. The protolophid II of *Reithroparamys* is short, not connecting with the metaconid to form a closed trigonid basin. The Inner Mongolian species has a well developed ectolophid, whereas some reithroparamyines, such as *R. debequensis* and *R. pattersoni*, have only a mesoconid or nothing.

The main distinctive characters of *Franimys* occur in its skull and limbs, but the genus is characterized also by having paracone and metacone of its upper molars well separated. This character is quite different from the condition in the Inner Mongolian species. Besides this, *Franimys* has a very short protolophid II.

M¹ and M² of *Rapamys* have two or three metaconules. Another of its main characters never appeared on other reithroparamyines—having a prominent but short posterior cingulid that is very close to the entoconid.

Family Cocomyidae Dawson, Li and Qi, 1984
Tamquammys Shevyreva, 1971
Tamquammys wilsoni Dawson, Li and Qi, 1984
(Figs. 7, 8; Table 2)

Holotype.—V5678, anterior portion of skull with broken incisors, right P⁴, left dP³–M².

Referred specimens.—V5679, right jaw with I, P₄–M₃; V5680, right jaw with M₁₋₃; V5681, M₁; V5682, M₂ (broken); V5683, left lower molar. All specimens came from one nodule.

Locality.—Huhe Bulak.

Discussion.—Discoveries in recent years have led to clarification of the classification of Ctenodactyloidea (Dawson et al., 1984). Only one family, Ctenodactylidae, was recognized when Simpson (1945) established the superfamily Ctenodactyloidea. Now, two other ctenodactyloid families, Cocomyidae and Yuomyidae, have been established.

Distribution of *Tamquammys* is middle Eocene in Kazakhstan and Inner Mongolia. Revised diagnosis of *Tamquammys* is as follows (Dawson et al., 1984, pp.

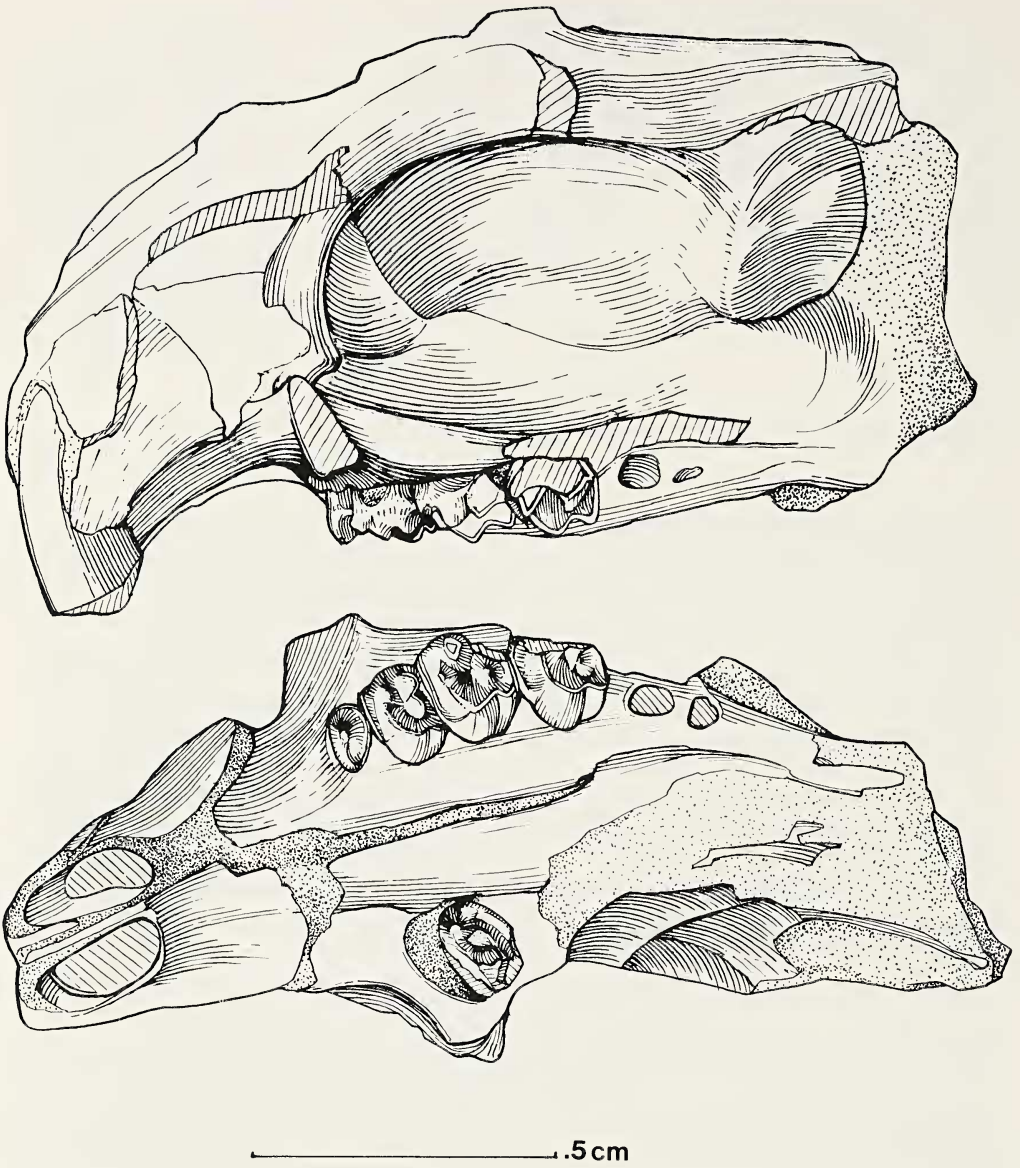


Fig. 7.—*Tamquammys wilsoni*. Holotype, V5678, skull, left lateral and palatal views.

142–143): “Ctenodactyloid rodent with skull hystricomorphus, lower jaw sciurognathous. Cheek teeth increase in size from front to back, have well developed conules in upper teeth, well developed lophs in lowers. P^4 with single buccal cusp. P_4 with relatively short and narrow talonid.” *Tamquammys wilsoni* has the following diagnosis: “Smaller than *T. tantillus*; P_4 has talonid less well developed posterobuccally, hypoconid-hypoconulid ridge more oblique, less transverse in orientation.”

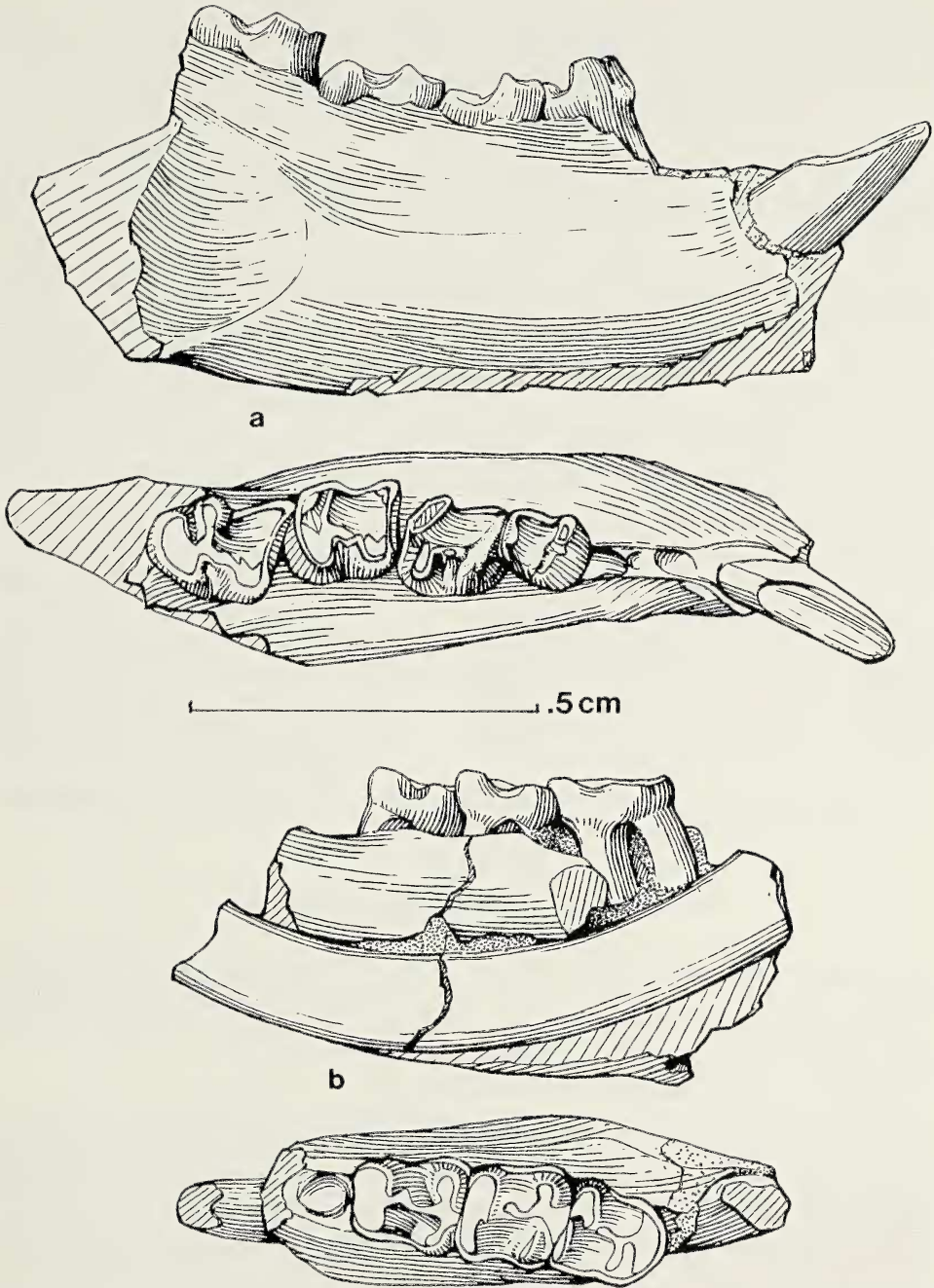


Fig. 8.—*Tamquammys wilsoni*. (a) V5680, lateral and crown views; (b) V5681, medial and crown views.

Order Acreodi Matthew, 1909
 Mesonychidae Cope, 1875
Mongolonyx Szalay and Gould, 1966
Mongolonyx dolichognathus Szalay and Gould, 1966
 (Fig. 9)

Holotype.—AMNH 26661, lower jaw with several well-preserved teeth, coronoid processes broken off; collected during the 1930 Central Asiatic Expedition; AMNH field no. 895.

Referred specimens.—AMNH 26662 (AMNH field number 907), a complete left maxilla with P²–M². Newly referred specimens V5690, M² (field number 77039); V5691, M₂ (field number 77031).

Localities.—7 miles west of Camp Margetts (type), Huhe Bulak, Bayan Ulan.

Discussion.—When Szalay and Gould (1966) described this species, they mentioned the uniqueness of M²: “The last molar, M², is the best preserved and most diagnostic tooth in the maxilla. The paracone is at least twice the size of the protocone, while the small metacone is connate with the posterior wall of the paracone. M² is only about two-thirds as wide as the preceding M¹.”

Newly discovered specimens from Inner Mongolia are two teeth: M² (V5690) and M₂ (V5691). Characters of M² are: 1) paracone twice the size of protocone; 2) metacone very small; 3) labial tooth wall convex; and 4) cingula very weak. M₂ has a prominent paraconid (although broken), a very strong protoconid, a relatively weak hypoconid. The enamel ridge at the base of the tooth is almost a straight line. M² (V5690) is quite similar to that of AMNH 26662 in both size and morphology, and M₂ (V5691) is close also to M₂ of the type specimen. Discovery of these two teeth establishes the geological provenance of *Mongolonyx dolichognathus* as the Arshanto beds.

Measurements.—L/W: M² (V5690) 26.3/27.2 mm, (AMNH 26661) 26.8/27.9 mm; M₂ (V5691) 31.2/16.5 mm; (AMNH 26662) 32(?) /16.5.

Mesonyx Cope, 1872
Mesonyx sp. cf. *M. obtusidens* (Cope, 1872)
 (Figs. 10, 11; Table 3)

Referred specimens.—V5692: left P⁴, with three roots (field no. 77036-2); V5696.1, M² (field no. 77027); V5693: M², with three roots (field no. 77036-2); V5694: lower canine (field no. 77027); V5695, 1–2: P₃ or P₄ (field no. 77027); and V5696: M₃ (field no. 77026).

Localities.—Huhe Bulak and Irdin Manha area.

Description.—P⁴: paracone larger than protocone; parastyle prominent; metastyle very weak. M²: protocone slightly larger than paracone, two convex crests on labial wall of protocone, protocone wall flat between the two crests; parastyle smaller in size; metacone larger; parastyle and metacone oblique; metastyle low but clear; extremely worn cingulum on buccal wall, clearer near metastyle; anterior edge of tooth concave, whereas posterior edge is relatively straight.

P₃ (or P₄): paraconid small cusp; protoconid large, relatively far back; position of hypoconid much lower than that of protoconid; no cingulum. M₃: crown narrow and low; paraconid relatively prominent; protoconid larger; length of hypoconid two-thirds length of whole tooth.

Discussion.—Cope (1872) first reported *Mesonyx obtusidens*, but the most complete skull (AMNH 12643) with upper cheek teeth was described by Matthew (1907). According to the descriptions of Matthew, M¹ of this species has a metastyle. Morphologically, the Inner Mongolian specimen is quite similar to AMNH 12643 at least in crown view. However, the Inner Mongolian specimen is larger

Table 3.—*Measurements (mm) of Mesonyx sp. cf. M. obtusidens.*

	L	W	L	W
P ⁴ (V5692)	15.6	14.8		
M ² (V5693; V5696.1)	19.7	18.3	20.0	17.5
P ₃ (V5695-1)	19.2	8.5		
P ₄ (V5695-2)	19.7	9.8		
M ₃ (V5696)	16.9	7.3		

and the parastyle and metacone are oblique, whereas those of AMNH 12643 are almost erect. The M₃ found at locality 77026 is unusual and is only tentatively referred to this species.

V5696.1, an M², is similar to V5693 (M²), except for the absence of a metastyle and being longer (L, 20.0 mm; W, 17.5 mm).

Hapalodectes Matthew, 1909

Hapalodectes? serus (Matthew and Granger, 1925)

(Fig. 12)

Referred specimen.—V7316, a broken lower jaw with posterior part of M₂ and single root of M₃ (field no. 77027).

Locality.—Huhe Bulak.

Discussion.—Matthew and Granger (1925*b*) described two mesonychids, *Hapalodectes serus* (only one tooth) and *H. auctus*, the former being smaller than the latter. M₂ of V7316, which is broken anteriorly, resembles that of *Hapalodectes serus*: it is hypsodont and the crest of the posterior part is sharp. There is a shallow masseteric fossa on the lower jaw.

Measurements.—AMNH 20172 (lower cheek tooth): 5.6 mm; V7316: 5.3 mm (ca.).

Order Pantodonta Cope, 1873

Family Coryphodontidae Marsh, 1876

Metacoryphodon, new genus

Type species.—*Metacoryphodon luminis* new genus, new species.

Diagnosis.—Larger than *Coryphodon*; unlike *Eudinoceras*, P²⁻³ protocristae present, canine more robust and longer.

Metacoryphodon luminis, new species

(Fig. 13; Table 4)

Holotype.—V5697, a broken skull with canines (not complete), right P¹–M³ and left P²–M³ (field no. 1P₅H₈).

Locality.—Ulan Bulak.

Diagnosis.—Canine extremely robust; P² and P³ with apparent pre-protocristae; post-protocristae tend to disappear; M³ has trace of paracone, ectoloph very long on the molars.

Description.—Nasal bone (broken) wide transversely, postcanine diastema not long; frontal bone wide and flat; zygomatic arch very strong. C¹: very robust; transverse section round; the growing directions of the two canines not upright, but inclined outward. P¹: no protocone; paraloph longer than metaloph; cingulum developed. P²: protocone strong with apparent pre-protocrista and weak post-protocrista; pre-protocrista extends downward and becomes a part of anterior cingulum, but not connected to inner cingulum; paraloph and metaloph very long, the two joining to form a “V”; parastyle more swollen than metastyle. P³: pre-protocrista and post-protocrista are developed but weak; parastyle

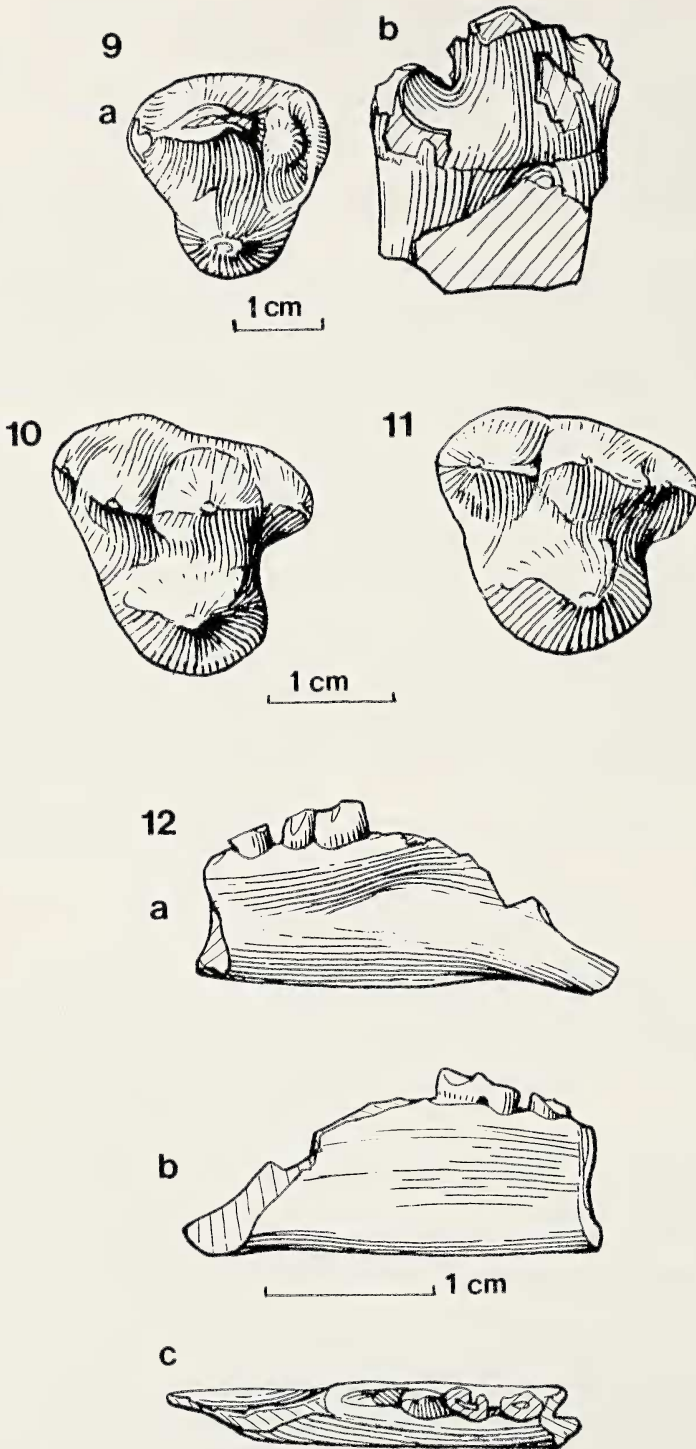


Fig. 9.—*Mongolonyx dolichognathus*. (a) V5690, left M²; (b) V5691, M₂.

Fig. 10, 11.—*Mesonyx* sp. cf. *M. obtusidens*. 10. V5693, right M². 11. V5696.1, right M².

Fig. 12.—*Hapalodectes?* *serus*. V7316, lower jaw. (a) external, (b) internal, (c) crown view.

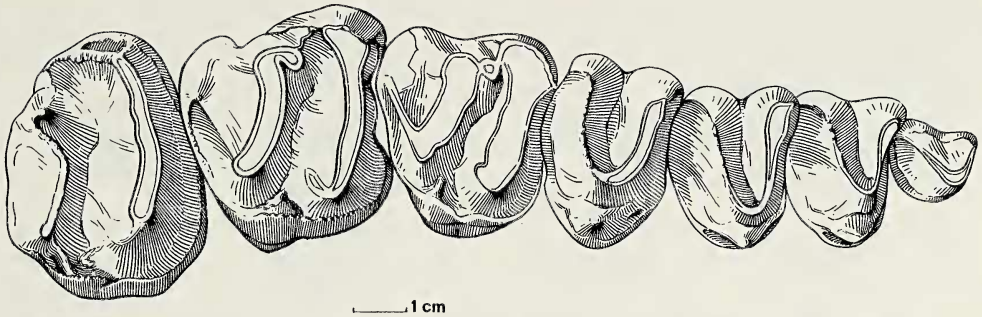


Fig. 13.—*Metacoryphodon luminis* new genus, new species. Holotype, V5697, right P¹–M³, crown view.

close to metastyle, so the valley between paraloph and metaloph is narrow. P⁴: pre-protocrista very weak; some crenulations on the anterior cingulum; post-protocrista weak, so protocone almost isolated. M¹: protocone high; protoloph almost parallel with ectoloph; parastyle relatively prominent; hypocone small, but distinct; metastyle swollen; cingulum present on anterior, inner, and posterior sides of crown, but not buccally. M²: quite similar to M¹; ectoloph long; hypocone relatively large. M³: wider but shorter than M²; protoloph very long, with trace of paraconule; parastyle low; paracone isolated; ectoloph short, its central part convex anteriorly; no metastyle.

Discussion.—Some characters of this species are intermediate between *Coryphodon* and *Eudinoceras*. The type specimen was found in 1977 by the staff of the Inner Mongolian Geological Mapping Team. In size it is close to *Eudinoceras mongoliensis* but larger than *Coryphodon*.

Eudinoceras mongoliensis (P³ or P⁴) was first described from Irдин Manha beds by Osborn (1924). In 1931, Osborn and Granger described another species, *E. kholobolchiensis*, from Kholobolchi Nor Basin, Mongolian People's Republic and, in 1932, described ?*Eudinoceras mongoliensis* from a lower jaw with cheek teeth. Many years later, Tong and Tang (1977) reported a new species, *Eudinoceras crassum*. During the summer field season of 1975, the author and the staff of Geological Mapping Team of Inner Mongolia discovered a broken skull and lower jaw of *Eudinoceras mongoliensis* with upper and lower incisors, canines, and cheek teeth on one side.

Although there are some differences between *E. mongoliensis* and *E. kholobolchiensis*, protocones of P² and P³ in both are isolated, that is, there are no pre-protocristae and post-protocristae. *Metacoryphodon luminis* has apparent pre-

Table 4.—Measurements (mm) of *Metacoryphodon luminis* (V5697).

	L	w
C ¹	37.0	41.0
P ¹	19.0	17.0
P ²	25.5	34.8
P ³	27.0	37.9
P ⁴	27.4	43.7
M ¹	38.0	43.6
M ²	46.5	52.4
M ³	44.4	57.1
P ¹⁻⁴	96.0	
M ¹⁻³	122.7	
P ¹ –M ³	216.6	

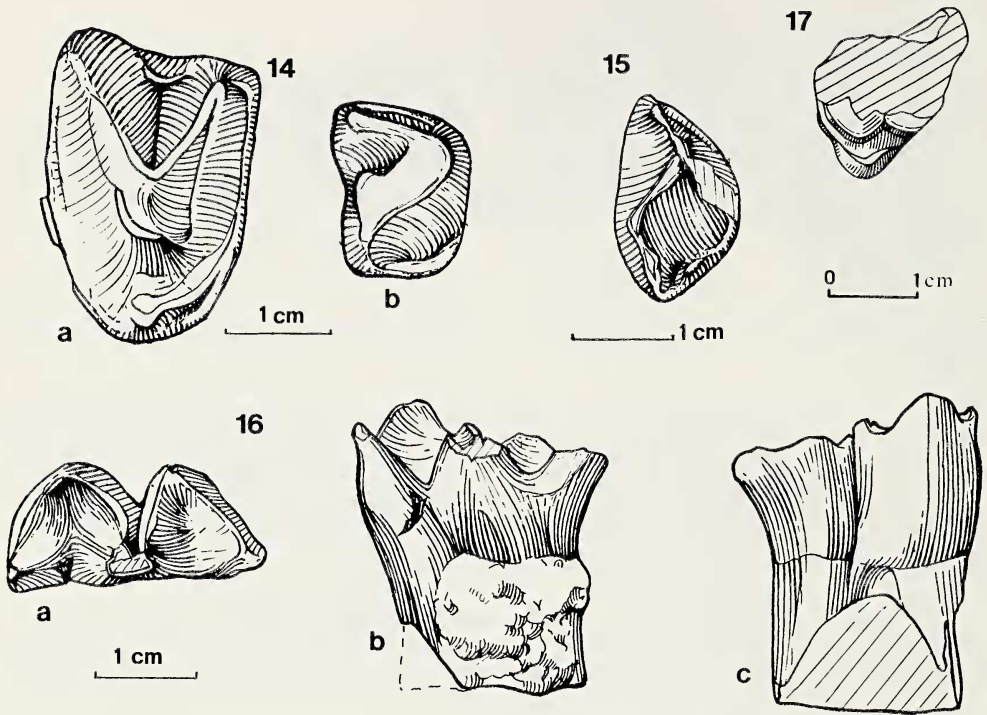


Fig. 14.—*Metacoryphodon?* *minor* new species. (a) Holotype, V5698, P²; (b) V5699, P₂.

Fig. 15.—*Metacoryphodon* sp. V5700, right P₁.

Fig. 16.—*Pantolambdaodon fortis*. V5687, right M₁. (a) crown, (b) internal, (c) external views.

Fig. 17.—*Pantolambdaodon?* *minor*. V5701, broken right M¹.

protocristae and weak post-protocristae on P² and P³. The canine of *E. mongoliensis* is inclined laterally and its crown is sword-shaped with saw-like edges, whereas the canine of *M. luminis* is more robust and longer and is directed anteriorly, as are the lower canines of ?*Eudinoceras mongoliensis*.

Coryphodon is somewhat smaller than *Metacoryphodon*. P¹⁻⁴ of *Coryphodon* have apparent pre-protocristae and post-protocristae.

Metacoryphodon is morphologically an evolutionary intermediate between early Eocene *Coryphodon* and the late middle Eocene *Eudinoceras* and *Hypercoryphodon*. In the evolution from *Coryphodon* to *Metacoryphodon* to *Eudinoceras* the pre-protocristae and post-protocristae gradually disappeared.

Metacoryphodon? *minor*, new species
(Fig. 14)

Holotype.—V5698, a right P² (field no. 77027).

Referred specimen.—V5699, a right P₂ (field no. 77039).

Locality.—Huhe Bulak.

Diagnosis.—Smaller than *M. luminis*; metastyle of P² more prominent than parastyle; opening of V-shaped valley formed by paraloph and metaloph is blocked by cingulum; pre-protocristae well developed, no post-protocristae; P₂ lacking outer and inner cingula.

Table 5.—Measurements (mm) of *Pantolambdodon inernis* and *P. fortis*.

	<i>Pantolambdodon inernis</i>						<i>Pantolambdodon fortis</i>			
	AMNH 21558		AMNH 22100		AMNH 21748		AMNH 26127		V5687	
	L	W	L	W	L	W	L	W	L	W
M ₁	20.0	9.5	20.0	11.0			29.0	13.0	27.8	14.5
M ₂	21.5	11.0	22.7	11.5						
M ₃			26.0	11.5	23.0	9.0				
M ₁ trigonid	11.5	9.0	11.0	10.0			16.0	13.5	14.0	14.0
M ₁ talonid	8.5	9.0	9.0	10.0			16.0	13.0	14.0	12.5
M ₂ trigonid	11.5	9.5	13.0	10.5						
M ₂ talonid	10.0	9.0	9.5	9.5						
M ₃ trigonid			15.0	11.0	12.5	9.5				
M ₃ talonid			11.0	8.0	11.0	7.0				

Discussion.—Both teeth are small. P² has well developed pre-protocristae, but no trace of post-protocristae. This character is quite different in *M. luminis*. The protocone of *M.?* *minor* is not as strong as that of *M. luminis*, its parastyle is relatively weaker, and there are no traces of a parastyle or metastyle. In addition, the opening of the V-shaped valley in *M. luminis* is not blocked by the cingulum.

Because no lower jaw of *M. luminis* is known, comparison with P₂ (V5699) is not possible. P₂ of *Metacoryphodon?* *minor* (L, 18.3 mm; W, 14.6 mm) is smaller than that of *Eudinoceras mongoliensis*, and following the size of P² (L, 22.3 mm; W, 32.2 mm), is certainly smaller than *M. luminis*.

Metacoryphodon sp.
(Fig. 15)

Referred specimen.—V5700, a right P₁ (field no. 77036H2).

Locality.—Huhe Bulak.

Discussion.—This tooth was found at a lower level. The size of P₁ is close to that of *Eudinoceras mongoliensis* but it shows several differences from that taxon: 1) paralophid of P₁ of *E. mongoliensis* is shorter and has a small cusp on the anterior end, whereas the paralophid of V5700 is longer and has two small cusps (one on the anterior end and another one at the middle of paralophid); 2) the paralophid and metalophid of *E. mongoliensis* are almost on a straight line, whereas the same lophids of V5700 form a V with a large opening; 3) V5700 has a cingulum behind the metastylid and a small cusp (worn) on the posterior end of the metastylid, whereas these are absent in *Eudinoceras mongoliensis*; 4) V5700 has no cingulum, but P₁ of *E. mongoliensis* is enclosed by cingulum at the base of the crown.

Measurements.—P₁ (V5700), L: 22.1 mm, W: 13.1 mm.

Family Pantolambdodontidae Granger and Gregory, 1934

Pantolambdodon Granger and Gregory, 1934

Pantolambdodon fortis Granger and Gregory, 1934

(Fig. 16; Table 5)

Holotype.—AMNH 26127, fragmentary right ramus of lower jaw with M₁ and alveoli of all anterior teeth.

Referred specimen.—V5687, a right M₁ (field no. 77027).

Localities.—8 miles north of Tukhum Lamasery; Huhe Bulak.

Discussion.—The first fossils of this taxon were found in 1925 and 1928, and

the systematic position of this family was reached by roundabout means. When Granger and Gregory (1934) studied these materials, they first decided that they "are dealing with a placental mammal of some sort from the fact that the dental formula: I_3, C_1, P_4, M_3 , is the classic primitive eutherian formula." They made many comparisons between the Mongolian types and many kinds of mammals, such as some South American mammals, chalicotheres, titanotheres, artiodactyls, condylarths, and dinoceratans.

At last, Granger and Gregory (1934, pp. 5–6) discovered that these Mongolian types are related to pantodonts: "When we come to *Pantolambda* and *Titanoides*, however, we find some apparently reliable indications of remote relationship to the Mongolian types, especially in the form of the premolars and molars. In spite of the fact that *Titanoides* is a graviportal form almost as big as *Coryphodon*, it shares the following features with the Mongolian fossils: (1) Dental formula of primitive placental type; (2) P_1, P_2 compressed; (3) talonid fossa of premolars formed between the posterior ridge connected with the main cone and a transverse metaconid ridge; (4) molar talonids with V-shaped crests; (5) talonid of M_3 narrower than trigonid; (6) M_3 with reduced or no hypoconulids; (7) M_1, M_2 with no trace of hypoconulid; (8) molars not crowded but slightly spaced; (9) coronoid process inclined backward. *Titanoides* is distinguished from the Mongolian forms by its relatively gigantic size, powerful, more erect incisors and canines; relatively shorter, more massive jaw, etc.

"From *Pantolambda* the present form differs in its much more elongate slender jaw, somewhat procumbent front teeth, more hypsodont cheek teeth, compressed premolars; the molars have much larger anterior V's and smaller posterior V's; the ascending ramus sloped backward and is distinctly delicate."

Ye (1983) referred to this family several teeth collected in Ulan Shireh, which was the type locality of this genus. A broken maxilla with upper cheek teeth was found in Aliusu. These cheek teeth, now under study, belong to a species of this genus.

Pantolambdodon has two species, *P. inermis*, and *P. fortis*. The main differences between the two species are in size, the former smaller, the latter larger. The newly discovered specimen (V5687) is similar to *P. fortis* in both size and morphology. The tooth has a shallow valley anterior to the crista obliqua, which has never been seen on other specimens.

***Pantolambdodon? minor*, new species**
(Fig. 17)

Holotype.—V5701, a broken M^1 (field no. 77026; L, protocone to parastyle, 21.0 mm).

Referred specimen.—V6706, a left M_1 (*Pantolambdodon inermis* of Ye, 1983; L/W of trigonid, 15/6.5 mm).

Localities.—Irdin Manha area, Ulan Shireh area.

Diagnosis.—Small size, pre-protocrista short; post-protocrista long; distance between paracone and metacone short, having a small metastylid on M_1 .

Description.— M^1 : protocone strong; pre-protocrista short, extending down anteriorly; post-protocrista long, extending down posteriorly; paracone and metacone relatively robust; distance between paracone and parastyle relatively long; mesostyle preserved only as a small piece of crest. M_1 : angle of V-shaped crest is 55° , metastylid apparent, smaller in size (Ye, 1983).

Discussion.—The two teeth were found at different localities: V5701 from Arshanto beds in the Irdin Manha area; V6706 from Ulan Shireh (beds). Although

V5701 (M^1) is broken on the buccal side, the diagnostic part is well preserved, allowing comparison between this M^1 and an undescribed specimen from Aliusu (see *P. fortis* above). The distance between protocone and parastyle is two-thirds that in the Aliusu specimen, while the distance between protocone and the base of mesostyle is only half that in the Aliusu specimen. However, the two specimens share some features: protocone very well developed; pre-protocrista and post-protocrista similar; paracone close to metacone; and roots underneath paracone-parastyle equally robust.

Order Dinocerata Marsh, 1873

Family Uintatheriidae Flower, 1876

Gobiatherium Osborn and Granger, 1932

Gobiatherium mirificum Osborn and Granger, 1932

(Figs. 18, 19, 20a-c, 21, 22; Table 6)

Holotype.—AMNH 26624, a complete and nearly perfect skull.

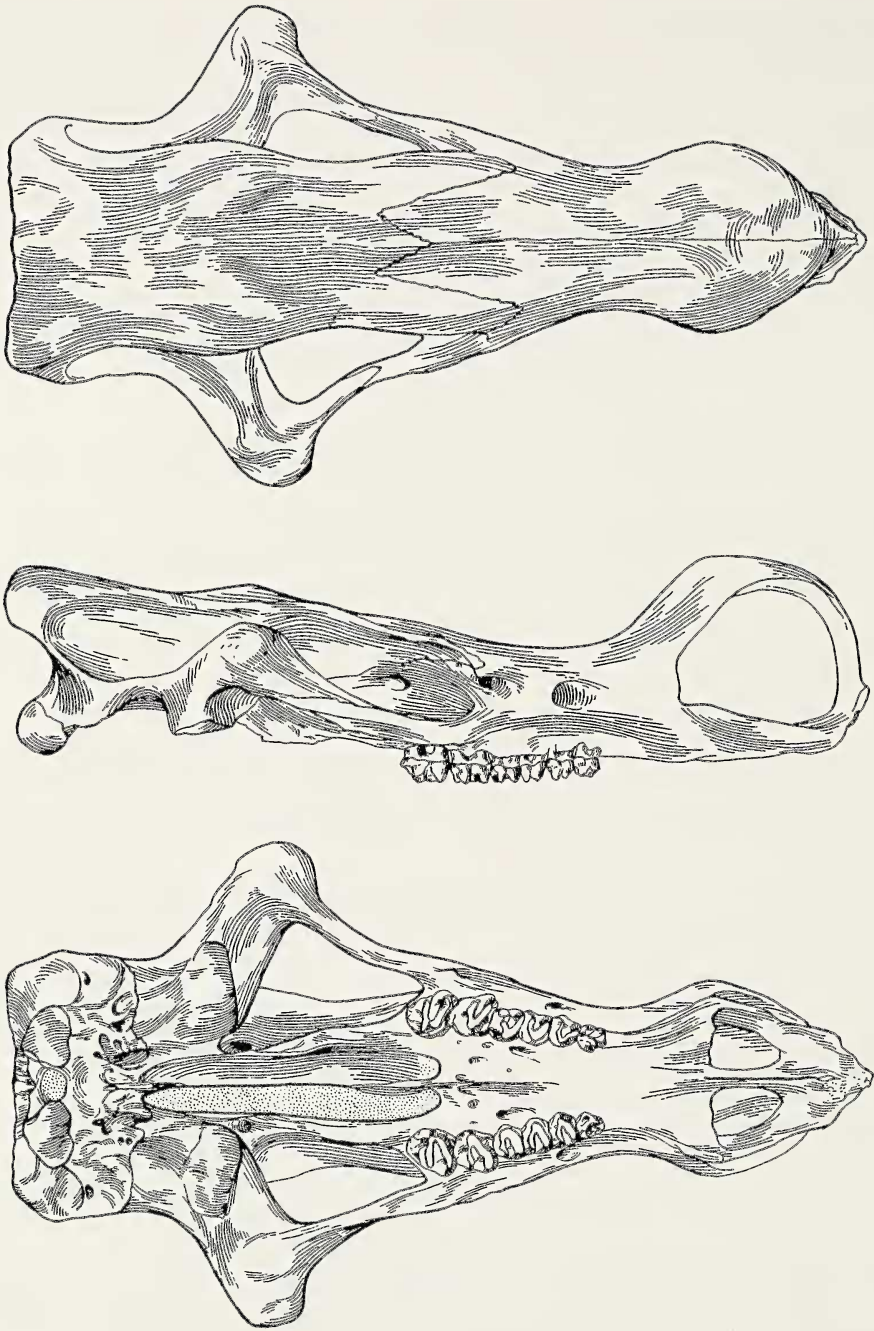
Paratype.—AMNH 26630, a nearly complete pair of lower jaws, lacking the incisors.

Referred specimens.—V5702: broken right maxilla, with P^{3-4} , M^{2-3} and left M^1 (field no. 77036-2); V5703: broken P^4 (77034); V5704: right lower jaw with P_2 – M_3 (77036-2); V5705: broken lower jaw with right P_2 – M_3 (M_2 and M_3 heavily broken) and left P_{3-4} (field number 1P₅H₈); V5706: left M_3 (77036-2); V5707: right M_3 (77036-2); V5708: posterior part of left M_3 (77036-2); V5709: incisor (77021); V5710: lower jaw of a juvenile with dP_2 – M_1 (77036-2).

Localities.—25 miles southwest from Iren Dabasu; Huhe Bulak; Arshanto Obo.

Description.— P^3 : in crown view nearly quadrangular, paraloph and metaloph forming "V"; paraloph somewhat convex anteriorly; paracone very prominent, its apex pointing posterolingually; a lingual cuspule, the paraconule, near the paracone; metaloph straight; metaconule relatively prominent; anterior and posterior cingula very wide, connecting at base of protocone and inclined somewhat upward; external cingulum very weak. P^4 : paraloph more convex anteriorly; paracone prominent, but smaller than on P^3 ; rib-like crest on posterolingual side of paracone; metaloph straight; relatively prominent metaconule forming rib-like crest; anterior and posterior cingula very well developed; no external cingulum; P^{3-4} retain some trace of cement. M^1 : paraloph straight; paraconule and metaconule present; metaloph relatively straight; anterior and posterior cingula narrower than on P^{3-4} or M^{2-3} ; weak external cingulum. M^2 : paraloph relatively straight; paracone somewhat swollen; metaloph straight; metaconule present; cusp, possibly hypocone, on central part of posterior wall of protocone; anterior cingulum gradually widened from labial to lingual side; posterior cingulum also wide; anterior and posterior cingula separated at base of protocone; no external cingulum. M^3 : largest of upper cheek teeth; paracone swollen; paraconule present; distinct, saddle-like pit between paraconule and protocone; metacone prominent; metaconule present (although broken); anterior cingulum wide; posterior cingulum probably wide (also broken). I_1 (more than half preserved) characteristically notched. P_2 : smallest of lower cheek teeth; protoconid high; paraconid low; protoconid-metaconid-hypoconid forming a crest; hypoconulid forming posterior cingulum; with trace of cement. P_3 : paraconid very small; metaconid high; protoloph straight; mesoconid large and low; cingulum lying anterior to paracone on lingual side; hypoconulid forming posterior cingulum; trace of cement behind hypoconid. P_4 : larger in size but otherwise similar to P_3 . M_1 : paraconid prominent; vertical crest of hypoconulid faint; distance between posterior cingulum and transverse crest (both formed by hypoconulid) is long, forming a wide posterior shelf. M_2 : (V5706) metaconid high; mesoconid prominent; paraconid distinct; hypoconulid forming posterior cingulum; entoconid very prominent. M_3 : (V5705) largest tooth; protoconid and paraconid distinct, joined by low crest; metaconid high; mesoconid prominent; hypoconid parallels hypoconulid; entoconid somewhat swollen and forming rib-like crest.

Juvenile (V5710): body of lower jaw rather slender; ascending ramus wide anteroposteriorly; masseteric fossa shallow; short dP_1 – dP_2 diastema. dP_2 : rather long anteroposteriorly; paraconid and mesoconid distinct; protoconid very high; metaconid relatively prominent; mesoconid clear; hypoconid forming a transverse crest and connected to mesoconid; hypoconulid forming posterior cingulum. dP_3 : crown view quadrangular; paraconid relatively prominent; anterior cingulum extremely weak; hy-



0 7.2CM

Fig. 18.—*Gobiatherium mirificum*. Holotype, AMNH 26624, dorsal, lateral, and palatal views of skull (from Osborn and Granger, 1932).

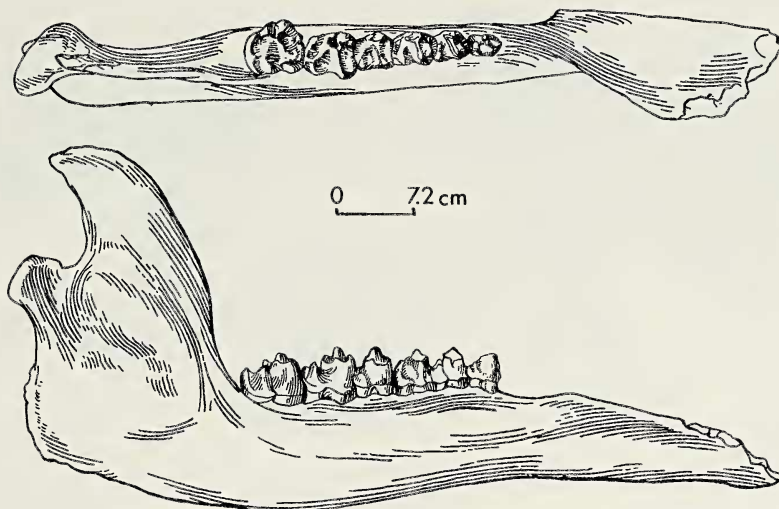


Fig. 19.—*Gobiatherium mirificum*. Paratype, AMNH 26630, lateral and crown views. The anterior alveolar border is restored from the left side (from Osborn and Granger, 1932).

poconulid forming posterior cingulum. M_1 : similar to type specimen, but distance between hypoconid and hypoconulid longer, vertical crest of hypoconulid longer and posterior cingulum (formed by hypoconulid) wider.

Discussion.—The newly discovered specimens are similar to the type specimen, but because Osborn and Granger (1932) gave only a simple description of the type, a more complete description is given here.

The type specimen was found in the “Camp Margetts” area; that is, the present Huhe Bulak-Ulan Bulak area. V5709 was found in the Arshanto Obo area.

***Gobiatherium? major*, new species**
(Fig. 23)

Holotype.—V5712, two broken lower jaws, associated, with left dP_3 and M_1 and right dP_4 , M_1 , and M_3 (posterior part) (field no. 1P₃H₈).

Locality.—Ulan Bulak.

Diagnosis.—Large size; M_1 protoconid very prominent; “shelf” formed by M_3 hypoconulid and entoconid very low, flat, not steep, and relatively wide.

Description.— dP_3 : larger than dP_4 ; hypoconid crest relatively long; hypoconulid large and wide. dP_4 : small; protoconid not prominent; almost no hypoconulid. M_1 : large; protoconid very prominent; protolophid straight and wide; hypoconulid transversely wide. M_3 (only posterior part): hypoconulid anteroposteriorly long, transversely wide and forming a wide “shelf”; entoconid distinct; hypoconulid crest and entoconid crest very weak.

Discussion.—This species differs from *G. mirificum* in that: 1) dP_4 of *G. mirificum* is larger than dP_3 , whereas dP_4 of this species is smaller than dP_3 ; 2) protoconid of *G. mirificum* is very weak or absent, whereas the protoconid of this species is large and prominent; 3) on M_3 of *G. mirificum*, the hypoconulid and entoconid are very steep and form the posterior cingulum, whereas hypoconulid and entoconid in this species form a low, flat, wide shelf.

Measurements.—L/W: dP_3 , 23.0/17.4? mm; dP_4 , 19.5?/18.0 mm; M_1 , 29.0/24.0 mm.

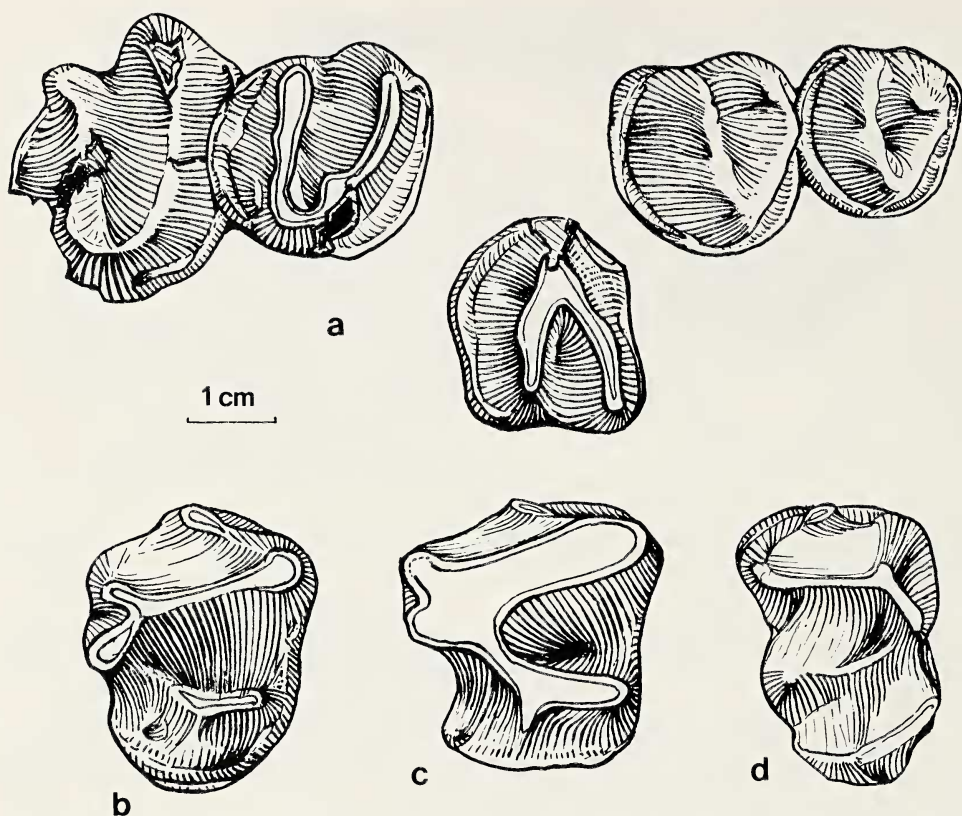


Fig. 20a-c.—*Gobiatherium mirificum*. (a) V5702, right P^{3-4} , M^{2-3} , and left M^1 ; (b) V5707, (c) V5706, both M_3 . Fig. 20d. Cf. *Uintatherium* sp. V5711, right M_3 .

Gobiatherium? monolobotum, new species
(Fig. 24)

Holotype.—V5713, 1-6: I_1 ($I_2?$), two I_3 (partly broken); left P_2 and P_3 , M_3 (posterior part) (field no. 1P₂₅H₈).

Referred specimens.—V5713, 7-8: two incisors (field no. 77036-2).

Localities.—Ulan Bulak; Huhe Bulak.

Diagnosis.—Crown of incisor not notched.

Description.— I_1 : small; external wall smooth; straight crest from top to base on internal wall; top of crown pointed; no notch along crown edge. I_3 : robust in size; in external view, crown caret-shaped; a relatively robust and straight crest runs from top to base on internal wall (another crest may parallel this crest, but this is not clear as tooth is broken). P_2 : metaconid and metastylid distinguishable; relatively large. P_3 : protoconid formed by protoconid, metaconid, and metastylid; direction of protoconid oblique to that of lower jaw; hypoconid prominent, extends forward forming oblique crest; oblique crest not joined to protoconid; posterior cingulum developed. M_3 : protoconid robust; talonid long; hypoconulid very strong, but apex not pointed.

Discussion.— P_2 and P_3 of this species are similar to those of *Gobiatherium mirificum*, but the incisors are quite different: the crown edge in *G. mirificum* is notched and the internal wall lacks a straight crest from the top to the base. M_3 of *G. mirificum* also is larger than that of this species.

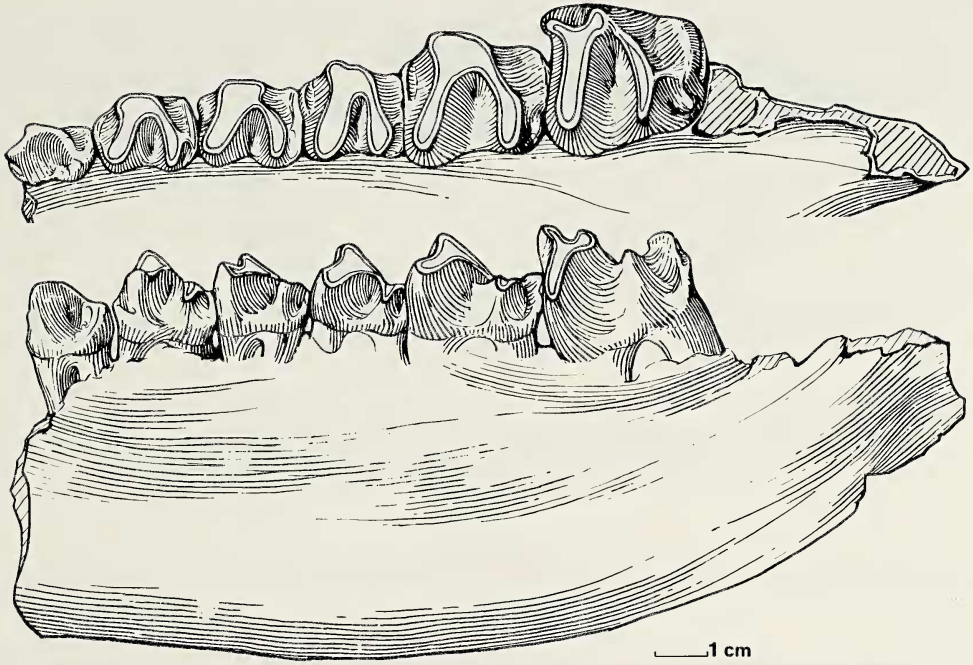


Fig. 21.—*Gobiatherium mirificum*. V5704, lower jaw with P_2 – M_2 , crown and external views.

Measurements.—L/W: I_1 , –/10.5? mm; I_3 , 27.0/15.0 mm; P_2 , 20.5?/14.0? mm; P_3 , 22.0/16.5 mm; M_3 , –/23.0 mm.

cf. *Uintatherium* sp.
(Fig. 20d)

Referred specimen.—V5711, right M_3 (field no. 1P₅H₈).

Locality.—Ulan Bulak.

Discussion.—In crown view M^3 is apparently narrower than M^3 of *Gobiatherium*, its paraconid is more prominent and its entoconid somewhat swollen.

Measurements.—L: 35.7 mm; W: 25 mm.

Order Perissodactyla Owen, 1848
Suborder Tapiroidea Gill, 1872
Family Isectolophidae Peterson, 1919
Homogalax Hay, 1899
***Homogalax reliquius*, new species**
(Fig. 25)

Holotype.—V5748, right M_3 (field no. 77036-2; L, 14.9 mm; W, 7.2 mm).

Referred specimen.—V5747, left M_3 (field no. 77034; L, 15.3 mm; W, 6.8 mm).

Locality.—Huhe Bulak.

Diagnosis.— M_3 with single robust hypoconulid; metalophid well developed; trigonid relatively long.

Description.—V5748 (M_3), crown wide anteriorly, narrow posteriorly, relatively high; posterior part of robust hypoconulid slightly turned toward lingual side; metalophid relatively well developed; tri-

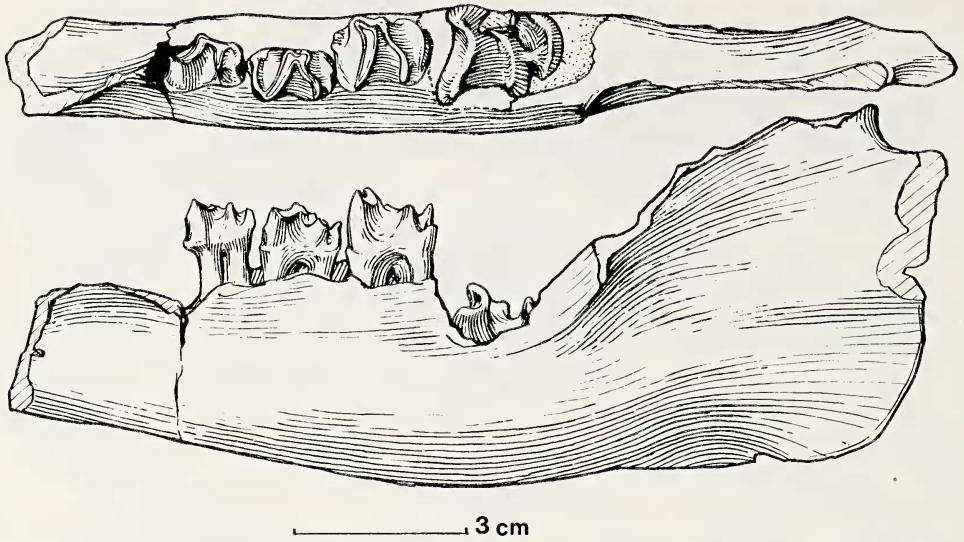


Fig. 22.—*Gobiatherium mirificum*. V5710, juvenile, lower jaw and cheek teeth, crown and external views.

gonid relatively long; weak development of cingulum at base of crown on labial side and behind hypoconulid.

The hypoconulid on V5747 (M_3) consists of two cuspules, of which the labial one is larger than the lingual; crown relatively high; labial cingulum at base of crown weak.

Discussion.—These M_3 s are unique among all Asiatic fossil tapirs because they have robust hypoconulids. The North American fossil tapirs *Homogalax* and *Isectolophus* bear robust hypoconulids. The former is early Eocene (Wasatchian), and the latter is middle and late Eocene (Bridgerian and Uintan). *Homogalax* is smaller than *Isectolophus*. On M_3 , the hypoconulid of *H. protapirinus* is smaller than that of *I. latidens*, but the hypoconulid of *I. annectens* is still larger. The Inner Mongolian specimen is similar to *Homogalax*. The hypoconulid of V5747 (M_3) consists of two cuspules, one labial, one lingual, whereas North American *Homogalax* may have an M_3 with two cuspules, one anterior, and one posterior.

The metalophid of the Inner Mongolian specimen is separate from the proto-lophid, while that of *Homogalax* and *Isectolophus* is still connected with the proto-lophid. This indicates that the Inner Mongolian specimen was more bilophodont. Also, the Inner Mongolian specimen resembles North American *I. latidens* (such as AMNH 10640) in having a longer trigonid, but the former is higher crowned.

Family Helaletidae Osborn, 1892

Heptodon Cope, 1882c

Heptodon minimus, new species

(Fig. 26; Table 7)

Holotype.—V5732, associated lower jaws, with left P_1 – M_3 and right P_2 – M_2 (field no. 77036-2).

Referred specimens.—V5733: left lower jaw, with P_2 – M_3 (77036-2); V5731, left M_3 (77027).

Locality.—Huhe Bulak.

Table 6.—Measurements (mm) of *Gobiotherium mirificum*.

	V5702			AMNH 26624			V5707			V5710			AMNH 26622*			
	L	W		L	W		L	W		L	W		L	W		
P ³	22.0	23.0		20.0	25.0											
P ⁴	24.0	25.3		21.0	27.0											
M ¹	24.0	28.0		23.0	25.0											
M ²	29.2	28.6		30.0	30.0											
M ³	34.7	34.4		35.0	32.0											
M ¹⁻³	88.0 (ca.)			91.0												
	V5704			AMNH 26624			V5707			V5710			AMNH 26622*			
	L	W		L	W		L	W		L	W		L	W		
dP ₂	20.7	17.5		20.0	12.0					15.0	9.2					
P ₂																
dP ₃										15.8	10.0		17.0	10.0		
P ₃	24.2	16.3		23.0	18.0					18.4	15.5		22.0	13.0		
dP ₄																
P ₄	24.5	19.2		23.0	21.0											
M ₁	25.5?	21.6		28.0	23.0											
M ₂	31.8	29.4		31.0	29.0											
M ₃	39.2	34.0		39.0	34.0											
Depth, mandible below M ₁	66.0 (ca.)	67.0					37.5	35.2								

* From Osborn and Granger (1932, Fig. 13).

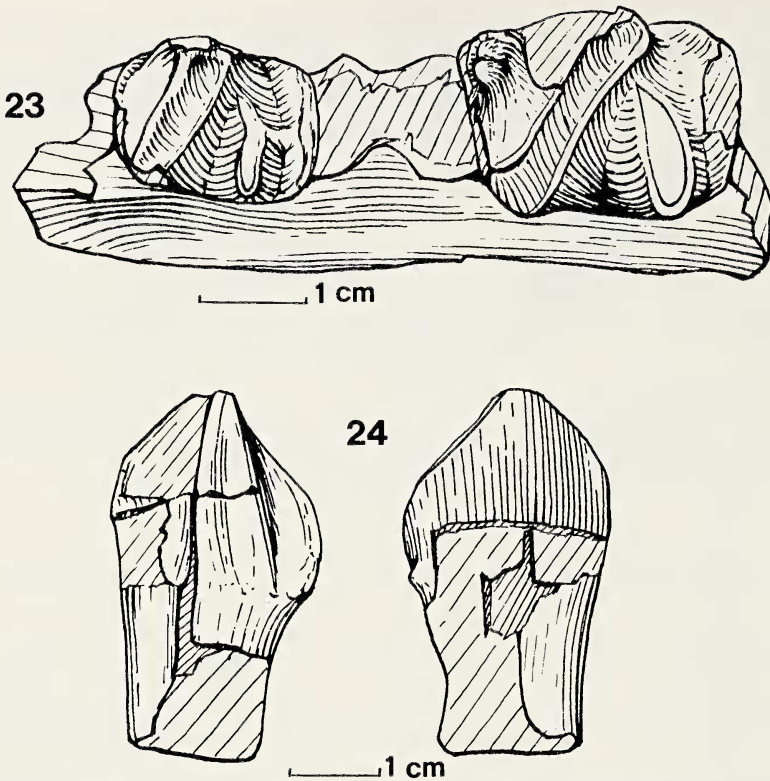


Fig. 23.—*Gobiattherium?* *major* new species. Holotype, V5712, right dP_3 , M_1 , crown view.

Fig. 24.—*Gobiattherium?* *monolobotum* new species. Holotype, V5713 (in part), incisor, internal and external views.

Diagnosis.—Main cusp on P_2 strong; P_4 entoconid present; hypoconulid of M_3 has two crests extending forward and connecting with hypolophid.

Description.— P_1 (V5732): protoconid high; posterior crest somewhat swollen; roots fused. V5733, P_2 : paralophid short; position of protoconid forward; metaconid not swollen; ectolophid relatively long, connecting with protolophid; entocristid distinct, also connecting with protolophid; no hypolophid; external cingulum extremely weak; no internal cingulum. P_3 : protoconid-paralophid-metaconid forming a semi-circle; ectolophid well developed and more lingual; entocristid connecting with metaconid; hypoconid small, not connecting with entoconid; external cingulum present; no internal cingulum. P_4 : metaconid not convex anteriorly, small notch between metaconid and protoconid; ectolophid developed; entocristid distinct; hypoconid small, not connecting with entocristid; external cingulum extremely weak; no internal cingulum. M_1 : paralophid distinct; metalophid short; hypoconulid triangular; external cingulum very weak; no internal cingulum. M_2 : triangular hypoconulid more prominent, connecting upward to top of hypolophid. M_3 : paralophid hooks ventrally; metaconid convex anteriorly; ectolophid relatively short; two crests extend from hypoconulid, a labial one anteroventrally, and a lingual one anterodorsally; a weak cristid crosses the hypoconulid valley antero-posteriorly.

Discussion.—The Inner Mongolian specimen (V5732) is quite different from North American earlier tapirs such as *Homogalax* and *Isectolophus*, being smaller, and bearing smaller hypoconulids.

Several North American tapirs such as *Helaletes*, *Dilophodon*, and *Colodon* have no P_1 , nor does the type specimen of *Heptodon calciculus* (AMNH 4858).

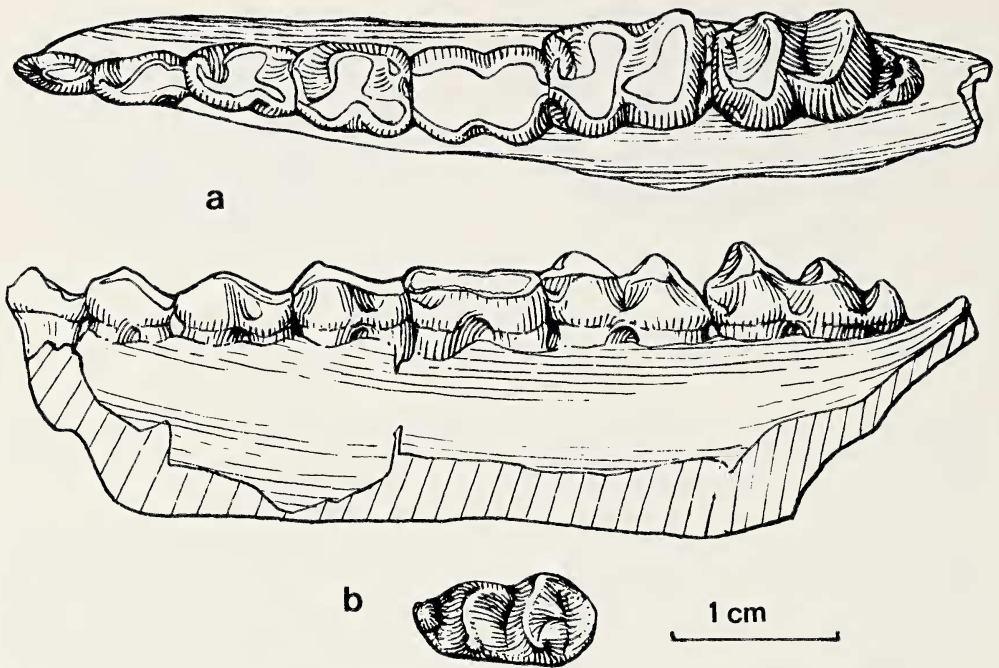


Fig. 26.—*Heptodon minimus* new species. (a) holotype, V5732 (in part), lower jaw with P_1 – M_3 , crown and lateral views; (b) V5731, M_3 .

Locality.—Ulan Bulak.

Diagnosis.—Metalophids of M_1 and M_3 relatively well developed, M_3 short anteroposteriorly, its hypoconulid very small.

Description.— P_4 : paralophid relatively lingual and oriented anteroposteriorly; paraconid not swollen; metalophid relatively well developed; top of hypolophid located almost at level of talonid basin; no entoconid; no internal cingulum. M_1 : hypoconid relatively well developed. M_2 : paralophid very short; protolophid and hypolophid present; two segments of cingulum occurring on the external wall; no internal cingulum; hypoconulid flexed dorsally. M_3 : paralophid relatively long; paraconid somewhat prominent; protolophid parallels hypolophid; metalophid extending forward and connecting with protolophid; hypoconulid small, but very distinct; buccal and lingual hypoconulid crests extend to base of hypolophid.

Discussion.—The position of the paralophid of P_4 of this species, as in *H. mongoliensis*, is closer to the lingual margin of the crown than to the labial margin as in *Schlosseria magister* and *Lophialetes expeditus*. *H. medius* has a very small entoconid, so its talonid is nearly flat. On P_4 in *Schlosseria magister* and *Lophialetes expeditus* the hypolophid is relatively well developed, but separated by a notch from the entoconid. An incomplete hypolophid occurs also in *Heptodontes mongoliensis*, but the entoconid is stronger. In addition, *H. medius* is smaller. These features indicate that P_4 of this species is more primitive in dental structure.

The hypoconulid of M_3 of this species is very small, and the style of connection between the two crests extending from hypoconulid and hypolophid is similar to that in *Heptodontes mongoliensis*. The hypoconulid of *H. mongoliensis* is larger, and the metalophids on the lower molars are not developed.

This species is similar to North American *Heptodontes nanus* in size, but the trigonids of P_4 – M_3 of the Inner Mongolian species are longer.

Table 8.—Measurements (mm) of *Heleletes medius*, *H. mongoliensis*, and *H. nanus*.

	<i>Heleletes medius</i>				<i>Heleletes mongoliensis</i> AMNH 20155		<i>Heleletes nanus</i> (Radinsky, 1963)	
	V592		V5730		L	W	L	W
	L	W	L	W				
P ₃	6.5?				9.75	7.30	6.8–8.7	4.5–5.9
P ₄	8.9	6.3			10.00	8.77	7.5–8.8	5.1–7.0
M ₁	9.1?	6.8			12.28	9.05	8.4–10.8	5.3–7.3
M ₂	11.8	8.0	11.4	8.5	14.55	10.35	9.9–11.8	6.3–7.9
M ₃	14.5	8.2	15.0	8.1	17.50	10.30	11.5–11.1	6.5–8.3
M ₁₋₃	36.4	35.4?						

Heleletes fissus (Matthew and Granger, 1925)
(Fig. 28)

Holotype.—AMNH 20161, maxillary fragment with P²⁻⁴.

Locality.—Near Camp Margetts.

Diagnosis.—"Slightly smaller than *Heleletes mongoliensis*, with P²⁻⁴ relatively shorter and wider, and hypocones better separated from protocones than in that species. P²⁻⁴ metalophs not so prominent as protolophs, and directed toward protocones" (Radinsky, 1965, p. 230).

Discussion.—Radinsky (1965) referred *Desmatotherium fissum* to *Heleletes fissus*, a new combination, and, although the geological position of this species was not clear at that time, Radinsky suggested that *H. fissus* and *H. mongoliensis* may occur in different horizons. His suggestion has proven to be correct.

It is not possible to make comparisons between *H. fissus* and *H. medius* because the former has only P²⁻⁴ and latter only lower cheek teeth. However, as Radinsky (1965, p. 231) pointed out, "The upper premolars of *Heleletes fissus* are more advanced than those of any other species of *Heleletes* . . ." The relatively primitive lower premolars of *H. fissus* suggest that it and *H. medius* are not the same species.

Heleletes fissus? (Radinsky, 1965)

Discussion.—The features of AMNH 81802 (C₁–M₃) studied by Radinsky (1965, p. 231) are advanced for *Heleletes* although "It is slightly smaller than *Heleletes mongoliensis* and agrees in size with the type of *H. fissus*." The P₃₋₄ of *Heleletes fissus?* have small entoconids, but nothing on P₄ is suggestive of *Heleletes medius*.

Hyrachyus Leidy, 1871

Hyrachyus neimongoliensis, new species

(Fig. 29)

Holotype.—V5721: an incomplete skull, with left P², P⁴, M¹ (partly broken), and M²⁻³ (field no. 77036-2).

Locality.—Huhe Bulak.

Diagnosis.—Frontal bone and nasal bone flat and straight; hypsodont; parastyles on molars very strong; paraloph almost parallel to metaloph; premolars non-molariform.

Description.—Skull: height low; posterior part of premaxilla narrow, body ascending abruptly, not gently; nasal bone flat and straight; posterior edge of nasal notch just anterior to P²; position of orbit low; frontal bone wide and flat; maxilla very long; zygomatic process of temporal bone and zygomatic process of molar bone join in mid part of zygomatic arch; zygomatic arch very long; suture between

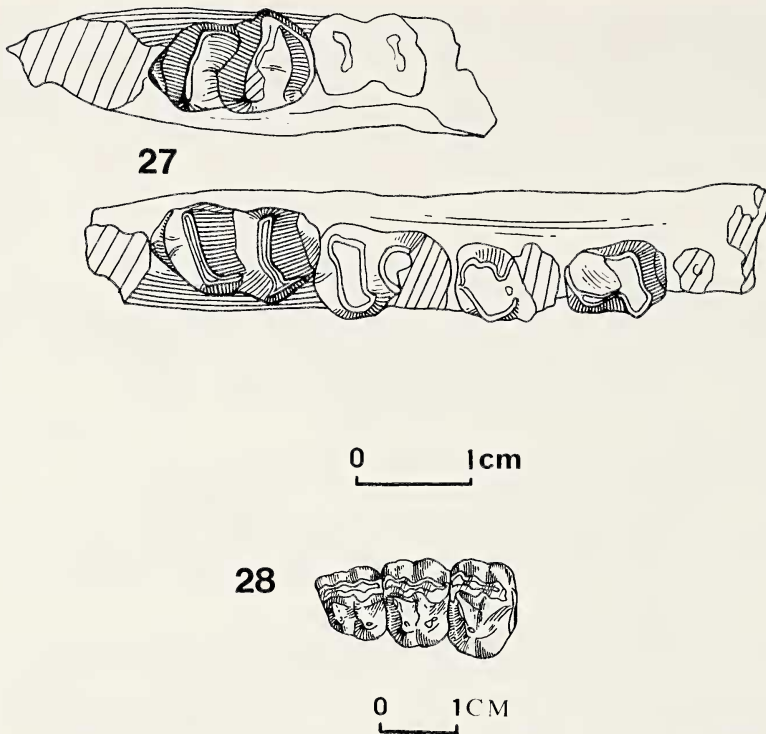


Fig. 27.—*Helaletes medius* new species. Holotype, V5729, lower jaws with left M_3 and right P_4 and M_3 .

Fig. 28.—*Helaletes fissus*. AMNH 20161, P^{2-4} (from Matthew and Granger, 1925c).

parietal and interparietal present; palatine process of maxilla narrow; median palatine suture clear; horizontal part of palatine narrow; basilar tubercles evident, separating basilar part of occipital and body of sphenoid; alar canal distinct; paramastoid process relatively large; mastoid process and occipital condyle relatively small; foramen magnum relatively large.

Upper cheek teeth: P^3 : paraloph connecting with ectoloph and protocone; attachment of paraloph and ectoloph lower than apex of protocone; hypocone distinct; metaloph connecting with ectoloph, and attachment of the two lobes higher than that of protoloph and ectoloph; anterior cingulum stronger than posterior cingulum; no external cingulum; paracone high, forming a rib-like and relatively robust crest on external wall; ectoloph straight. P^4 : larger than P^3 ; protocone robust, forming paraloph, which connects to ectoloph; paracone more prominent than metacone; two rib-like crests formed by these cusps on external wall (that is, anterior rib and posterior rib); anterior rib stronger than posterior rib; metaloph short, not connecting with paraloph; ectoloph straight; anterior cingulum distinct; no external cingulum. M^1 : (anterior part broken) middle part of paraloph swollen, may be result of wear of massive antecrochet; metacone long; angle between metacone and metaloph about 90° ; external wall of metacone flat and straight; anterior cingulum more distinct than posterior one. M^2 : largest of cheek teeth; paraloph robust; metaloph short; posterior part of ectoloph straight; paracone high; parastyle relatively robust; anterior cingulum clearer than posterior cingulum; no external cingulum; the angle between metacone and metaloph about 60° . M^3 : distance between paraloph and metaloph large, these two lobes almost parallel; paracone prominent; parastyle relatively strong; metacone (crest) short; angle between metacone and metaloph about 90° ; anterior cingulum wider than posterior cingulum.

Discussion.—Wood (1934, p. 189) pointed out the diagnostic features of *Hyrachyus*: “Hornless; protoloph of upper molars much more prominent than the metaloph; no tendency for the metalophs of the upper premolars to touch the crista; attachments of upper premolar metalophs to ectolophs usually higher than

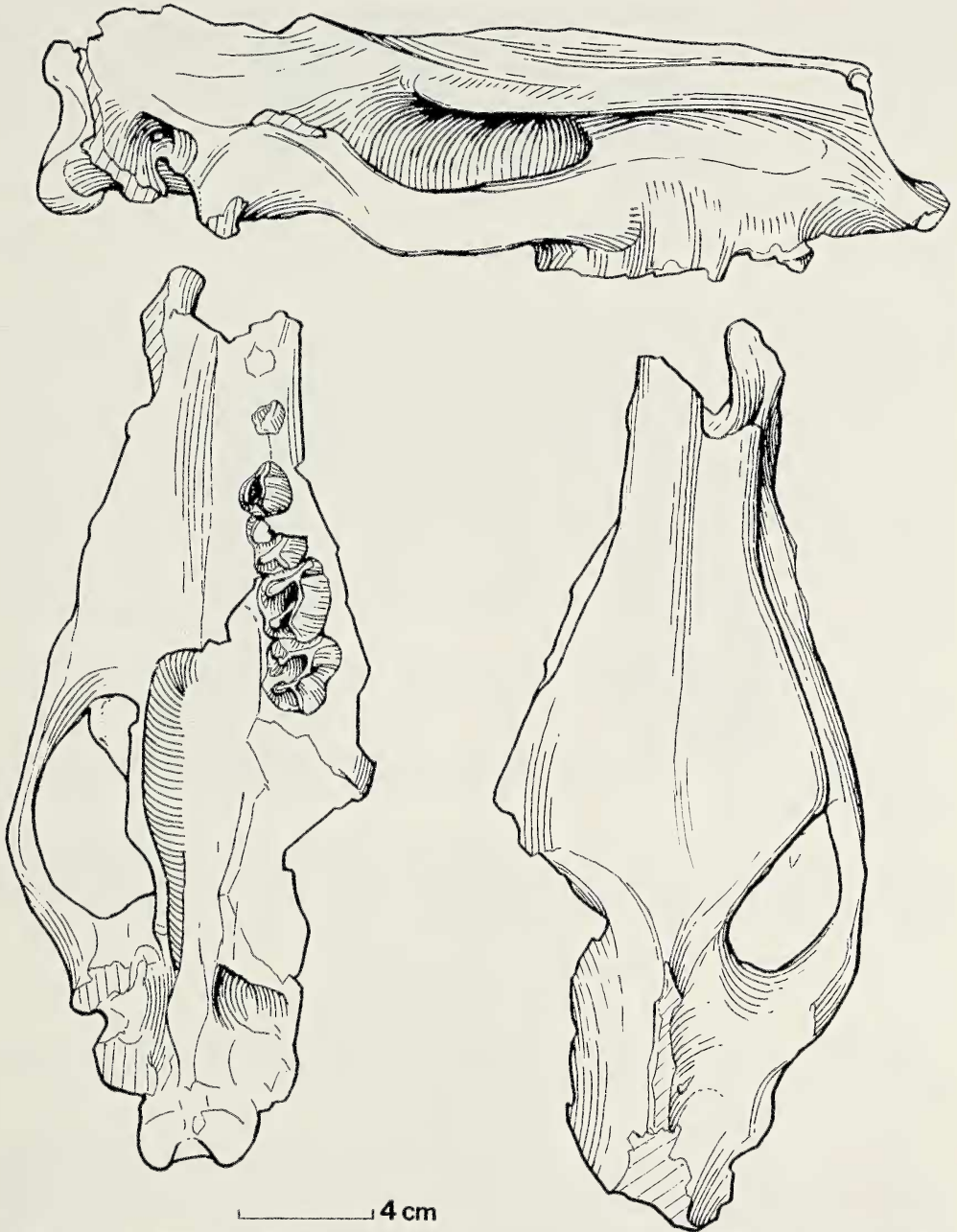


Fig. 29.—*Hyrachyus neimongoliensis* new species. Holotype, V5721, skull, lateral, palatal, and dorsal views.

corresponding attachments of the protohorns; upper cheek teeth subrhinocerine rather than rhinocerine, except after extreme wear.”

Radinsky (1967a, p. 21) also pointed out that *Hyrachyus* is: “A conservative group preserving into the Middle Eocene primitive dental and skeletal features

Table 9.—Measurements (mm) of *Hyrachyus crista*.

	V5722		V5723	
	L	W	L	W
P ⁴	13.5	17.5	14.5	18.3
M ¹	17.5	19.0	19.2	20.0
M ²	21.4	21.4	23.5	22.6
M ³	18.4	19.0		
M ¹⁻³	55.0			

seen in the earliest *Heptodon*. Incisors spatulate. Postcanine diastema present. P₁ retained; premolars non-molariform to submolariform. No tendency toward bilophodonty. M₃ without a hypoconulid. No nasal incision enlargement."

Unquestionably, the Inner Mongolian species is very close to the North American *Hyrachyus eximius* (= *H. princeps*, AMNH 12364). Both species have some similar characters in both skull and cheek teeth: 1) P⁴: attachments of metaloph to ectoloph higher than corresponding attachment of protoloph; 2) M³: parastyles strong, and paraloph is close to and almost parallels metaloph. The species have some differences: 1) the P⁴ of the Inner Mongolian species has no crochet, while the North American P⁴ does; 2) widths of the molars of the North American specimen are greater than lengths, while the Inner Mongolian specimen has the opposite condition.

M³ of *Hyrachyus metalophus* (Zhou and Qi, 1982) is somewhat smaller than this species, but has a very prominent external rib on the ectoloph. This is a primitive character.

The skull of this species bears some resemblance to that of *Forstercooperia huhebulakensis*: skull dimension; skull low and flat; zygomata slender; and the position of the bulla.

Measurements.—Skull: length between premaxilla and condyles, 365 mm; width, across zygomatic arch, 158 mm; depth of skull above M³, 81 mm; width of skull (postorbital constriction), 52 mm; width of condyles, 51 mm. Upper cheek teeth (L/W): P², 12.3/12.3 mm; P⁴, 16.1/21.3 mm; M¹, 26 (ca.)/21 mm (ca.); M², 30.5/27.3 mm; M³, 28.4/26.2 mm; (L): M¹⁻³, 77.0 mm (ca.).

Hyrachyus crista, new species

(Fig. 30; Table 9)

Holotype.—V5722, fragmentary maxilla with P⁴–M³ (field no. 77031).

Referred specimen.—V5723, fragmentary maxilla with left and right P⁴–M² (right P³ broken) (77031).

Locality.—Bayan Ulan.

Diagnosis.—Attachment of P⁴ metaloph to ectoloph higher than corresponding attachment of protoloph; internal cingulum distinct at the base of protocone; crochet on P⁴–M² very weak, but distinct on M³.

Description.—P³ (V5722, same below): only three alveoli remaining. P⁴: attachment of metaloph to ectoloph higher than corresponding attachment of protoloph; paracone and metacone forming two clearly rib-like crests (anterior rib and posterior rib); parastyle prominent; internal cingulum distinct at the base of protocone; crochet weak. On P⁴ of V5723, no crochet, internal cingulum forming indistinct semi-circle. M¹: parastyle prominent; paracone high, forming anterior rib; metacone relatively long, posterior rib very weak; ectoloph connected to metaloph, but attachment covered by cement; angle between metacone (crest) and metaloph smaller than 90°; metaloph higher than paraloph; external cingulum weak and short at the base of metacone; crochet very weak. On M¹ of V5723, posterior rib very weak; internal side of parastyle notched; no crochet. M²: similar to M¹, but parastyle stronger, crochet clearer, metacone longer. On M² parastyle on V5723 notched. M³: parastyle notched, not as

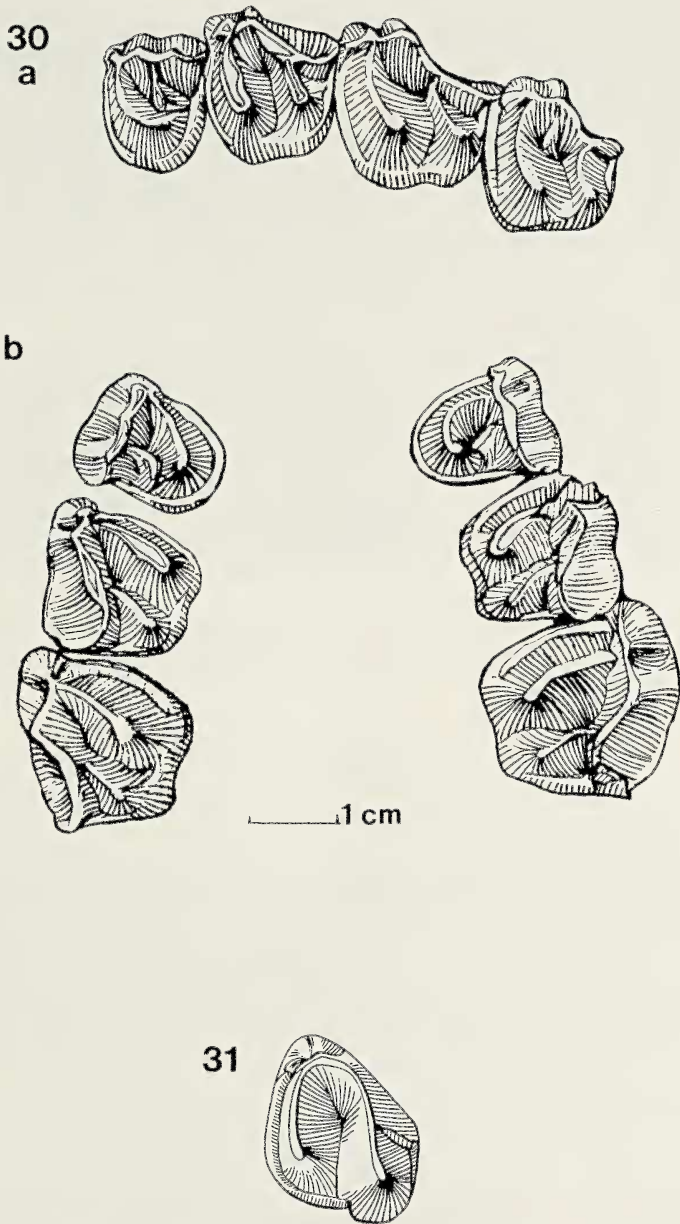


Fig. 30.—*Hyrachyus crista* new species. (a) Holotype, V5722, P⁴–M³; (b) V5723, left and right P⁴–M².

Fig. 31.—*Hyrachyus* sp. cf. *H. eximius*. V5728, left M³.

robust as on M²; crochet distinct; metacone straight; paraloph not close to metaloph but parallel to it; paracone high, forming prominent anterior rib.

Discussion.—Radinsky (1967a) referred one genus, *Hyrachyus*, to the Subfamily Hyrachyinae, and three species: *H. modestus* from North America, Europe, and China; *H. eximius* from North America and possibly from China; and *H. minimus* from North America.

Radinsky's (1967a, p. 22) diagnoses of these species are as follows:

1) *H. modestus*: "A small to medium-sized *Hyrachyus* species: mean length of M^{1-3} from about 45 to 50 mm. Premolars non-molariform. Upper molars usually lack lingual and labial cingula."

2) *H. eximius*: "Size large: mean length of M^{1-3} , 64 mm. Premolars non-molariform. Upper molars usually lack lingual and labial cingula."

3) *H. minimus*: "A medium-sized *Hyrachyus* species: mean length of M^{1-3} , about 50 mm. Premolars submolariform. Upper molars usually with labial and lingual cingula. M^3 metacone situated more labially than in other *Hyrachyus* species. In these features *H. minimus* is intermediate between other *Hyrachyus* species and *Chasmothereium cartieri*."

P^4 of the Inner Mongolian species is similar to *Hyrachyus modestus*, especially between V5722 and AMNH 12667. Both P^4 s have very prominent anterior and posterior ribs, and very prominent anterior and posterior cingula. Some different characters are apparent also on various P^4 s of *H. modestus*: 1) V5722 and AMNH 80183 have crochets, while V5723 and AMNH 12667 have no crochets; 2) V5723 has a semi-circle-like internal cingulum, lacking on AMNH 12667. M^{1-3} of the Inner Mongolian species are different from those of *Hyrachyus modestus* in the following points: 1) parastyle relatively small; 2) higher crown; 3) metacone elongated.

Apparently the genus *Hyrachyus* not only appeared in Asia, but its later members were broadly distributed in east Asia. *Hyrachyus modestus* appears closely related to *H. crista*.

Hyrachyus sp. cf. *H. eximius*
(Fig. 31)

Referred specimen.—V5728: left M^3 (field no. 77039).

Locality.—Huhe Bulak.

Discussion.—This tooth is similar to M^3 of *Hyrachyus eximius* (AMNH 12362) found in Bridger C beds, Wyoming. The main similarities are: 1) paraloph parallel to metaloph; 2) paraloph not close to metaloph; 3) degree of hypsodonty; 4) length/width ratio. The metacone of the Inner Mongolian specimen is weaker.

Compared to M^3 of *Colodon inceptus* (found in Inner Mongolia), the M^3 referred here is wider, and the attachment of the paraloph to the ectoloph is closer to that of the metaloph to the ectoloph. Both M^3 s have short metacones.

Measurements.—(V5728): M^3 (L/W), 14.4/22.0 mm.

Hyrachyus sp.
(Fig. 32)

Referred specimens.—V5724, left M^{2-3} (field no. 77028H₂); V5725, right P^4 (77036-2); V5726, right P^4 (77036-2); V5775, left M^3 (77039); V5776, right M^3 (77039).

Localities.—Daatein Obo, Huhe Bulak.

Discussion.—These specimens, collected from several sites, are too incomplete to be assigned with certainty. V5724 was found in Daatein Obo Cliff along with other fossil mammals, *Microtitan? elongatus*, *Forstercooperia grandis* and *Asiomys medius*. Characters of the two molars are as follows: M^2 : parastyle, a slender, prominent pillar; paracone high, forming a clear anterior rib; metacone long,

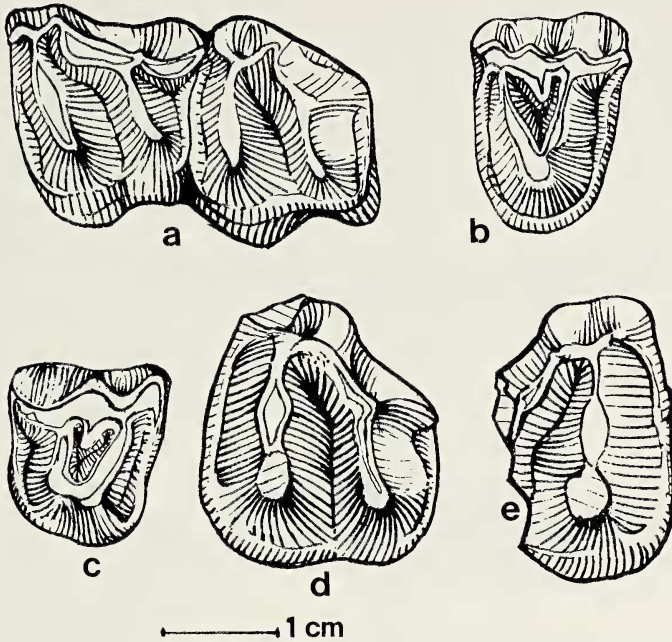


Fig. 32.—*Hyrachyus* sp. (a) V5724, M²⁻³; (b) V5725, P⁴; (c) V5726, P⁴; (d) V5775, M³; (e) V5776, M³.

without a clear posterior rib; cingulum around the base of the crown (except anterior edge); no crochet. M³: parastyle as on M² and separate from protocone; attachment of paraloph to ectoloph close to that of metaloph; metacone relatively long; anterior cingulum clear. M²⁻³ are similar to those of *H. crista* but they are smaller, have weaker parastyles that are slender, pillar-like and separate from the protocone, and lack a crochet on M³. Among these characters, the slender pillar-like parastyles are rarely seen in tapiroids.

On P⁴ (V5725 from the Irdin Manha beds) the paracone is very close to the metacone; the crochet is very well developed; the paraloph is not connected to the ectoloph and is relatively straight (the paraloph of *H. crista* is somewhat curved and hook-shaped); its metaloph is swollen as in *H. crista*.

P⁴ (V5726 from the Arshanto beds), in crown view, is nearly square, the crochet is strong, the metacone relatively long, and the paraloph is longer than and connected to the metaloph. This tooth differs from P⁴ of *Schlosseria magister* in its larger size; nearly square occlusal outline, strong crochet, and long metacone (crest). The length/width ratio of V5726 (P⁴) differs from that of North American *Hyrachyus modestus*. Also, the P⁴ metaloph of *H. modestus* is isolated, that is, not connected to the paraloph. The attachment of paraloph to ectoloph in V5726 is higher than the corresponding attachment of metaloph, in contrast to the usual condition.

V5775 (M³) and V5776 (M³) were found in Huhe Bulak area, and are *Hyrachyus*-like in that the paraloph of V5775 parallels the metaloph.

Measurements.—L/W (mm): M² (V5724), 17.0/18.3; M³ (V5725), 14.5/17.4; P⁴ (V5726), 13.2/18.7; M³ (V5775), 20.0/22.1; M³ (V5776), 23.0.

Table 10.—Measurements (mm) of *Schlosseria magister*.

	AMNH 20241		V5734		V5735		V5736		V5740		V5738			
	L	W	L	W	L	W	L	W	L	W	L	W		
P ¹	5.8	4.6												
P ²	6.45	7.8												
P ³	8.17	9.9			7.4	9.7								
dP ⁴											11.3?	11.3		
P ⁴	8.4	10.6	8.5	10.7	8.0	10.5			7.9	10.5				
M ¹	10.6	12.0	10.6	11.6	10.3	12.0			9.3	11.9				
M ²	11.7	13.15	11.4	12.4	12.8?	12.2?	12.3	14.2	11.9	12.0				
M ³	10.83	12.36	10.5	11.5			11.7	13.0	10.9	11.4				
M ¹⁻³			32.2						32.0					
	AMNH 20242-20245		V5734		V5743		V5741		V5737		V5745		V5744	
	L	W	L	W	L	W	L	W	L	W	L	W	L	W
C ₁					5.4	3.5								
I ₃					5.9	3.0								
P ₁	5.1	2.4												
P ₂	6.2	3.4			6.6	4.0					5.3			
dP ₃														
P ₃	8.6	6.15	7.8	5.3	8.2	5.5	7.7	5.9					8.4	4.0
dP ₄														
P ₄	8.9	6.55	7.8	6.0	8.2	6.2	8.1	6.5						
M ₁	10.6	7.6	10.0	7.0	10.2	7.0	9.3	8.0	10.0	7.2				
M ₂	11.5	7.95	11.0	7.4	11.1	7.7	10.4	8.0	10.9	8.9				
M ₃	15.2	7.5	15.4	7.0	14.8	7.2	15.0	7.6	15.2	7.5				
P ₁₋₄			2.6 (ca.)		27.3 (ca.)									
P ₁ -M ₃			62.5 (ca.)		62.5 (ca.)									
M ₁₋₃			36.5		35.8		34.9		35.2					
Diastema			14.8		14.0 (ca.)									
Depth of mandible below M ₁			17.8		19.0 (ca.)		17.2							



Fig. 33.—*Schlosseria magister*. Holotype, AMNH 20241, P¹–M¹ (from Matthew and Granger, 1926).

Family Lophialetidae Radinsky, 1965
Schlosseria Matthew and Granger, 1926
Schlosseria magister Matthew and Granger, 1926
 (Figs. 33, 34; Table 10)

Holotype.—AMNH 20241, upper and lower jaws, fore and hind feet.

Referred specimens.—V5734, associated maxillae with left and right P⁴–M³, lower jaw with P₂–M₃ (with P₁ alveoli); V5735, maxilla with P³–M²; V5736, maxilla with M²⁻³; V5737, lower jaw with M₁₋₃; V5738, maxilla with dP⁴–M² (field no. 77039); V5739, right M³; V5740, maxilla with P²–M³; V5741, lower jaw with P₃–M₃ (77036-2); V5742, 1–10, cheek teeth; V5743, lower jaw with left I₃, P₂–M₃ and right C, P₂–M₁; V5744, dP₃₋₄; V5745, lower jaw with P₁, P₃, and P₄ (77034).

Localities.—Irdin Manha area and Huhe Bulak.

Discussion.—Of the known fossil mammals in the Arshanto beds, *Schlosseria magister* is most abundant. It occurs throughout the Arshanto beds in the Huhe Bulak and Ulan Bulak areas. After studying Morris' field notes for 1923 and 1925, Radinsky (1964, p. 3) determined the precise location of the type locality: "the *Schlosseria* quarry . . . for the distance from it to Arshanto well is recorded as 3 miles"

Radinsky (1965, p. 197) found that, "In the Irdin Manha area the beds containing *Schlosseria* underlie those with *Lophialetes*, but in the Camp Margetts area both genera are recorded as coming from the same horizon." Our discoveries have confirmed this point at least in the Huhe Bulak (that is, Camp Margetts) area. In Radinsky's study of the early Tertiary Tapiroidea of Asia, he listed the differences between *Schlosseria* and *Lophialetes*, as follows: species of *Schlosseria* are "Medium sized lophialetids with premolar series long relative to molar series. Premolar and molar metacones short and slightly convex; loph and lophids relatively low and obtuse. P¹ with narrow posterolingual shelf. P²⁻⁴ with protoloph-metaloph loop. M²⁻³ relatively short and wide. P₂₋₃ relatively long and narrow, with long trigonids. Nasal incision not so enlarged as that in *Lophialetes*. Manus tridactyl" (Radinsky, 1965, pp. 199-200).

Although the new specimens are very similar to *Schlosseria magister* and differ from *Lophialetes expeditus*, the two genera share some characters and occur in the same beds. Therefore, the possibility should not be excluded that these are sexual differences. This needs more detailed study.

Ranga Rao (1972) described a new tapiroid, *Kalakotia*, and made detailed comparisons between *Kalakotia* and *Schlosseria* (or *Lophialetes*). Although there exist several apparent differences between these genera, such as *Kalakotia* being smaller in size and more primitive in tooth pattern, Rao referred this genus to the Lophialetidae because, "it is clear that *Kalakotia* bears more similarities in dental structure to the Mongolian forms: *Lophialetes* and *Schlosseria*, than to any other known tapiroid."

Schlosseria sp. cf. *S. magister*
(Fig. 35)

Referred specimen.—V5746, right M₃ (field no. 77034).

Locality.—Huhe Bulak.

Discussion.—On this M₃, two small crests extend from the hypoconulid and attach to hypolophid in a manner similar to that in *S. magister*. At the base of hypoconulid, labially, there is a cingulum that is not present in other species of *Schlosseria*, but the tooth is similar otherwise to Radinsky's (1965) *Schlosseria* cf. *Schlosseria magister*.

Measurements.—(V5746) L/W: 13.6/6.7 mm.

Lophialetes
Lophialetes expeditus Matthew and Granger, 1925
(Figs. 36, 37; Table 11)

Holotype.—AMNH 19163, maxilla with P¹-M³.

Referred specimens.—V5749, left M¹; V5750, right M³; V5751, maxilla with dP²⁻³ (field no. 77027); V5752, left M²; V5753, maxilla with dP³-M¹ (field no. 77036-2); V5754, maxilla with left dP¹ (broken)-M¹ and right dP³⁻⁴ (broken); V5755, jaw with left dP₂-M₁ and dP₃-M₁; V5756, lower jaw with dP₃ and M₃ (field no. 77039).

Localities.—Camp Margetts; Huhe Bulak.

Description.—dP¹ (V5754, largely broken): only the ridged internal edge can be seen. dP² (V5754): paraloph oblique, not parallel to metaloph; hypocone strong; metaloph straight; paracone high; crochet relatively clear; cingulum extremely weak. dP³: paraloph straight and long; the position of metaloph higher than paraloph; paracone and metacone very prominent; paracone rib and metacone rib clear; parastyle prominent; crochet relatively distinct; metastyle slightly prominent. dP⁴: paraloph long; a small crest between parastyle and paracone; paracone rib stronger than metacone rib; on left dP⁴ a

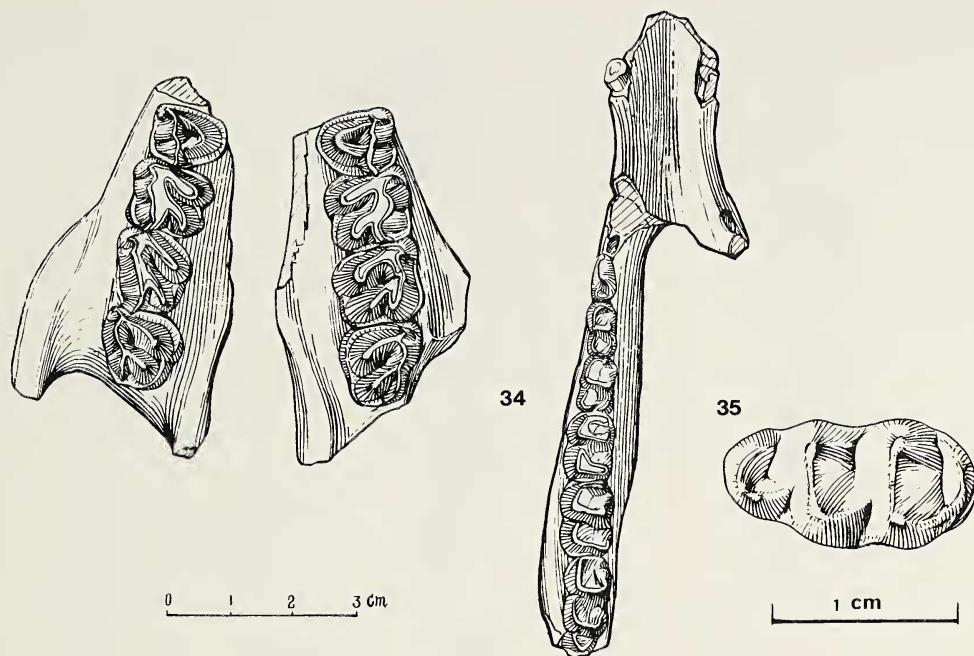


Fig. 34.—*Schlosseria magister*. V5734, palate with right and left P^4 – M^3 and lower jaw with C, P_2 – M_3 .
 Fig. 35.—*Schlosseria* sp. cf. *S. magister*. V5746, right M_3 .

secondary cuspule occurs at the base of hypocone. dP_1 (V5755), single-rooted. dP_2 : paraconid small but distinct; protolophid straight; protoconid highest cusp; metaconid close to paraconid; metalophid distinct. dP_3 : paraconid very prominent; paraconid not close to metaconid; protolophid relatively long; entoconid prominent, connects with hypoconid forming hypolophid; a small triangle-like process at position of hypoconulid. dP_4 : in crown view wider anteriorly than posteriorly; metaconid strong and convex anteriorly; distance from protoconid to anterior edge of tooth shorter than on dP_3 ; triangle-like process at hypoconulid position more prominent.

Discussion.—The differences between *Schlosseria* and *Lophialetes* were mentioned above. These new specimens are unquestionably *Lophialetes*. The milk teeth reported by Radinsky (1965) are also quite similar to the new specimens.

Breviodon Radinsky, 1965

Breviodon minutus (Matthew and Granger, 1925)
 (Figs. 38, 39, 40; Table 12)

Breviodon acares Radinsky, 1965, p. 203.

Holotype.—AMNH 20139, upper molar.

Referred specimens.—AMNH 26113 (holotype of *Breviodon acares*), left mandible with I_3 (reversed), C_1 , P_3 alveolus, and P_4 – M_3 ; V5757, maxilla with dP^{3-4} and M^1 ; V5758, dP^{3-4} (above field no. 77027); V5759, low jaw with M_{1-2} (broken) ($1P_{25}H_8$); V5760, low jaw with dP_4 (broken) and M_1 ($1P_{25}H_8$).

Localities.—Irdin Manha area (type locality of *B. minutus*), Ulan Bulak, Huhe Bulak, North Mesa, Ulan Shireh (type locality of *B. acares*).

Description.— dP^3 : in crown view nearly square; paraloph almost parallel to metaloph; paracone rib and metacone rib distinct; posterior cingulum very weak; no cingulum at the base of hypocone. dP^4 : similar to dP^3 , but paraloph more prominent; metacone flat and straight. M^1 : larger in size; lophs

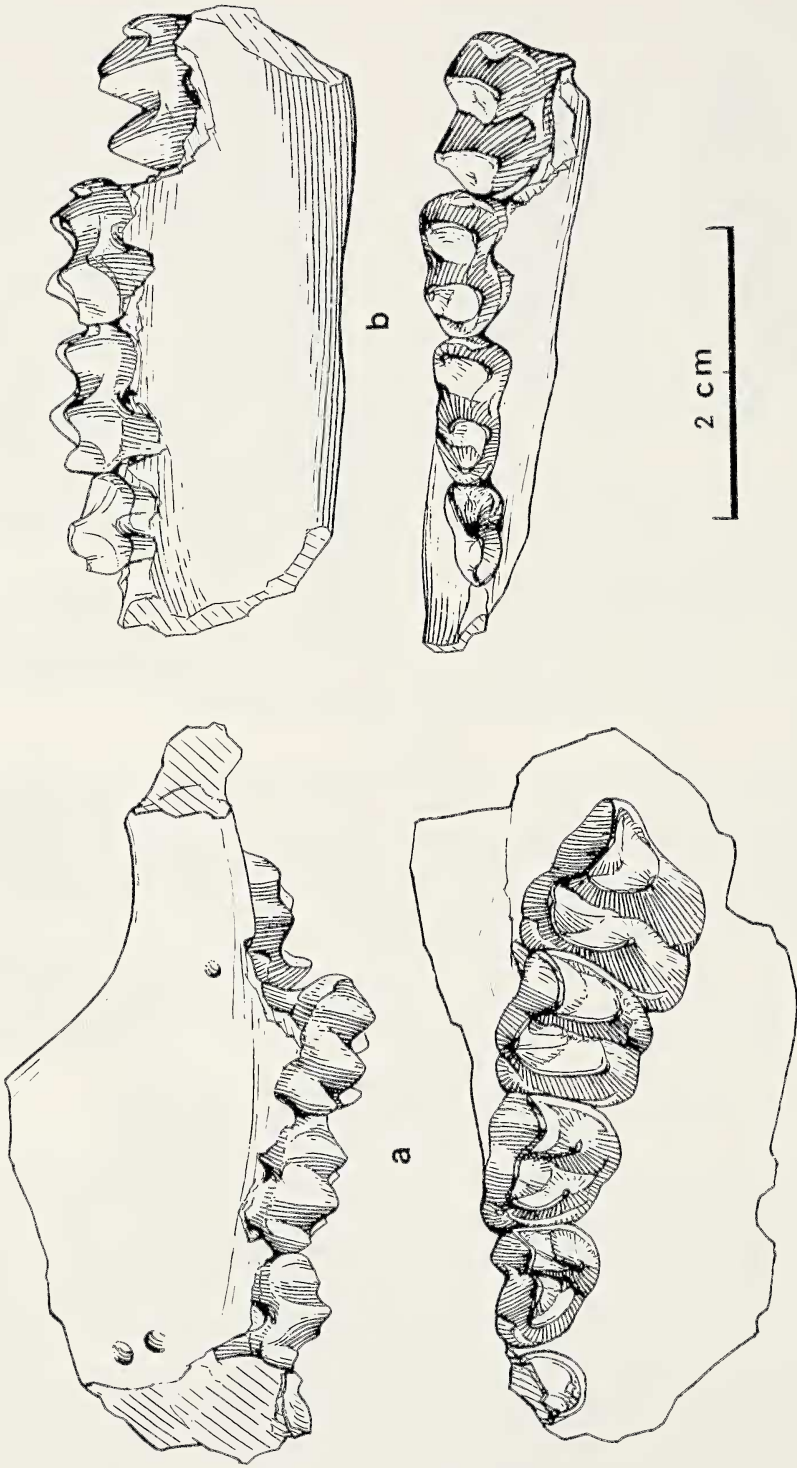


Fig. 36.—*Lophialetes expeditus*. (a) V5754, maxilla with dP¹-M¹; (b) V5755, jaw with left dP₂-M₁.

Table 11.—Measurements (mm) of *Lophialetes expeditus*.

	V5754		V5754 (left)		V5755		V5753		V5749		V5752		V5750	
	L	W	L	W	L	W	L	W	L	W	L	W	L	W
dP ¹	6.0?	4.7												
dP ²	7.8	7.3												
dP ³	9.0	9.3	8.9	8.9			9.2	9.6						
dP ⁴	9.6	10.4	9.8	9.8			9.5	10.5						
dP ¹⁻⁴	30.7 (ca.)						10.4	11.1						
M ¹	13.0	12.4							13.1	13.4				
M ²											15.0	15.0		
M ³													13.6	14.0
dP ₁														
dP ₂							4.2?							
dP ₃							7.0	3.6						
dP ₄							9.6	5.0						
dP ₁₋₄							9.3	5.7						
M ₁							29.6							
							10.3	5.7						

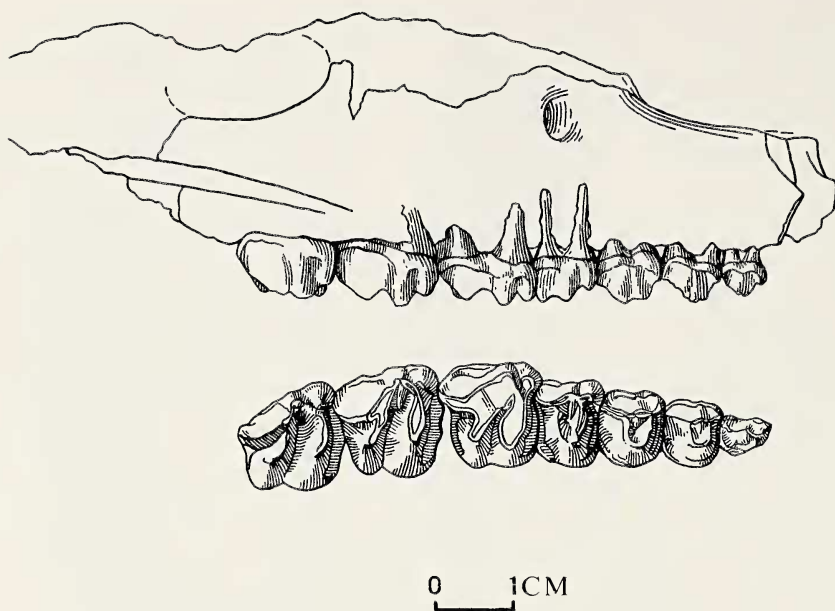


Fig. 37.—*Lophialetes expeditus*. Holotype, AMNH 19163.

slightly worn. dP_4 : (only posterior part preserved) the angle between ectolophid and hypolophid 90° ; the position of hypoconulid somewhat prominent. M_1 : anterior width almost the same as posterior width; metaconid distinct and convex anteriorly; a triangle-like process at the hypoconulid position. M_2 : (only posterior part preserved) ectolophid and hypolophid developed; slight prominence at hypoconulid position.

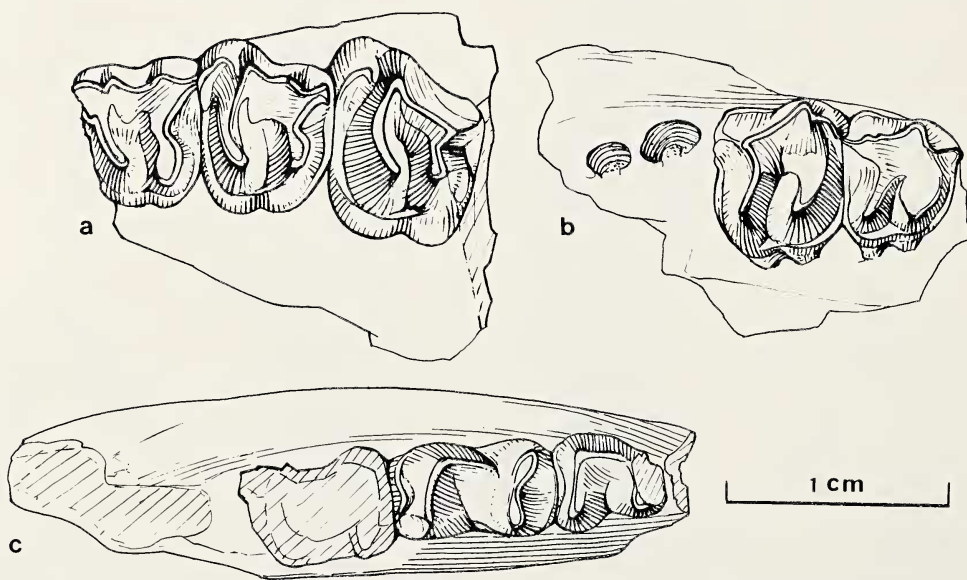
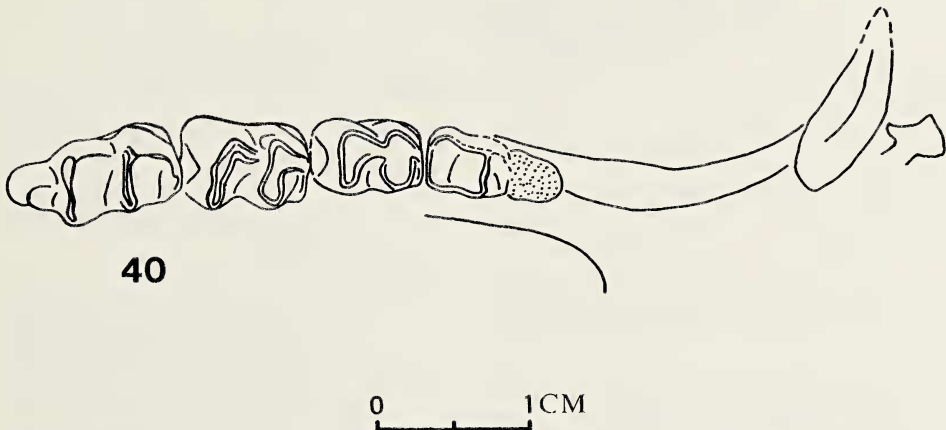
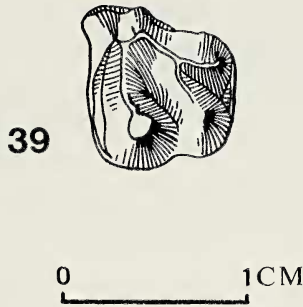


Fig. 38.—*Breviodon minutus*. (a) V5757, $dP^{3-4}-M^1$; (b) V5758, dP^{3-4} ; (c) V5760, dP_4-M_1 .



Figs. 39, 40.—*Breviodon minutus*. 39. Holotype, AMNH 20139 (from Matthew and Granger, 1925c, Fig. 8). 40. AMNH 26113, holotype of *B. acares*, left lower jaw with I₃ (reversed), C₁, P₃ alveolus and P₄–M₃.

Discussion.—*Breviodon* was erected by Radinsky (1965, p. 203) and diagnosed as follows: “Very small lophialetids, with premolar series extremely short relative to molar series; P₁₋₂ lost. Symphysis broad, postcanine diastema long. Lower molar cusp patterns like those in *Lophialetes*.” He named a new species, *Breviodon acares*, and referred *Lophialetes minutus* with question to this genus as *Breviodon*?

Table 12.—Measurements (mm) of *Breviodon minutus*.

	V5757		V5758		V5759		V5760	
	L	W	L	W	L	W	L	W
dP ³	5.8	6.3	5.4	5.5				
dP ⁴	6.5	7.3						
M ¹	7.8	8.6						
dP ₄								3.9
M ₁					7.9?	5.0?		
M ₂					8.8	6.3		

minutus. According to the material (associated upper and lower cheek teeth) found in Mongolia, Reshetov (1975) considered *B. acares* to be a synonym of *Breviodon? minutus*, a conclusion followed here.

V5757 (dP³⁻⁴ and M¹) fit with V5759 (M₁₋₂), so the two specimens are apparently associated. M¹ of V5757 fits with M¹ of *Breviodon minutus* (no. 3107-32) found in Mongolia, whereas the M₁ of V5759 is similar to that of "*Breviodon acares*" (AMNH 26113). This further confirms the synonymy of *B. minutus* and *B. acares*. On the anterior edge of dP³ of V5757 there seems to be a wear facet, suggesting the presence of dP².

Huang and Qi (1982) described a new species of *Breviodon*, *B. lumeiyiensis*, the teeth of which are similar to those of *B. minutus*, but smaller in size, the cheek teeth being twenty percent narrower than those of *B. minutus*.

Family Deperetellidae Radinsky, 1965
Teleolophus Matthew and Granger, 1925
Teleolophus primarius, new species
 (Fig. 41; Table 13)

Holotype.—V5761, mandible with P₂₋₄ and M₁₋₂ (field no. 1P₅H₇).

Referred specimens.—V5762, mandible with M₂₋₃ (77027); V5763, 1-21: associated teeth, several carpi, and phalanges (including left P₃, M₁, and M₂ (77036-2); V5764, 1-2: two M₁ (77039); V5764, 1-2: two M₁ (1P₅H₈).

Localities.—Ulan Bulak, Huhe Bulak.

Diagnosis.—The metalophid is labial on P₂, but not labial on P₃ and P₄; premolars lacking entoconids; three pairs of incisors.

Description.—P₂: metalophid near labial edge of crown; protoconid very close to metaconid; paraconid somewhat swollen; a rib-like crest on the internal wall of hypoconid; external cingulum relatively strong; internal cingulum incomplete. P₃: protoconid and metaconid clearly separate; no hypolophid; a rib-like crest on the internal wall of hypoconid; trigonid longer than talonid. P₄: paralophid short; trigonid relatively short; talonid longer than trigonid. M₁: protolophid parallel to hypolophid; no metalophid; anterior cingulum weak; posterior cingulum very short. M₂: paralophid very wide anteroposteriorly; anterior cingulum below the paralophid very weak; no metalophid; protolophid almost parallel to hypolophid. M₃ (V5762): similar to M₂ but posterior root curved posteriorly. Radiale (carpal bone): five facets, of which the facet that articulates with radius is the largest; two facets articulate with intermediate carpal, the distal of them narrow and long, and the proximal, wide and short; the other two facets are larger and articulate with the second and third carpal. Intermediate carpal bone: a total of seven facets—one flat facet articulates with the radius, two facets articulate with radiale (the proximal one is wide, the distal, narrow), two facets articulate with ulnar carpal(?), and the other two facets articulate with the third and fourth carpal bones. Fourth carpal bone: roughly triangular in proximal view; in distal view, wider anteriorly than posteriorly; seven facets for articulations—two with intermediate and ulnar carpal bones, three with third carpal bone and another two with third and fourth metacarpal. First phalanges: three different phalanges, under the second, third, and fourth metacarpals, respectively. Second phalanges: the one under second metacarpus is widest. Third phalanges: proximal surface with two facets; dorsal surface rough.

Discussion.—These specimens were found in adjacent sites, so the known distribution of this species is restricted. The main difference between *Teleolophus* and *Deperetella* is that the premolar series in the former is shorter than the molar series. Although P₁ and M₃ were not found on one specimen of *Teleolophus*, the length of P₂₋₄ is equivalent to M₁₋₂. Therefore, the length of the P₁₋₄ must be shorter than M₁₋₃.

The differences between *T. primarius* and *T. medius* (found in 1975, now under study) are as follows: 1) the three incisors are aligned anteroposteriorly in *T. primarius* but form a triangle in *T. medius*; the third incisor of *T. medius* is greatly reduced, and the canine is more robust; 2) the symphysis is narrower in *T. pri-*

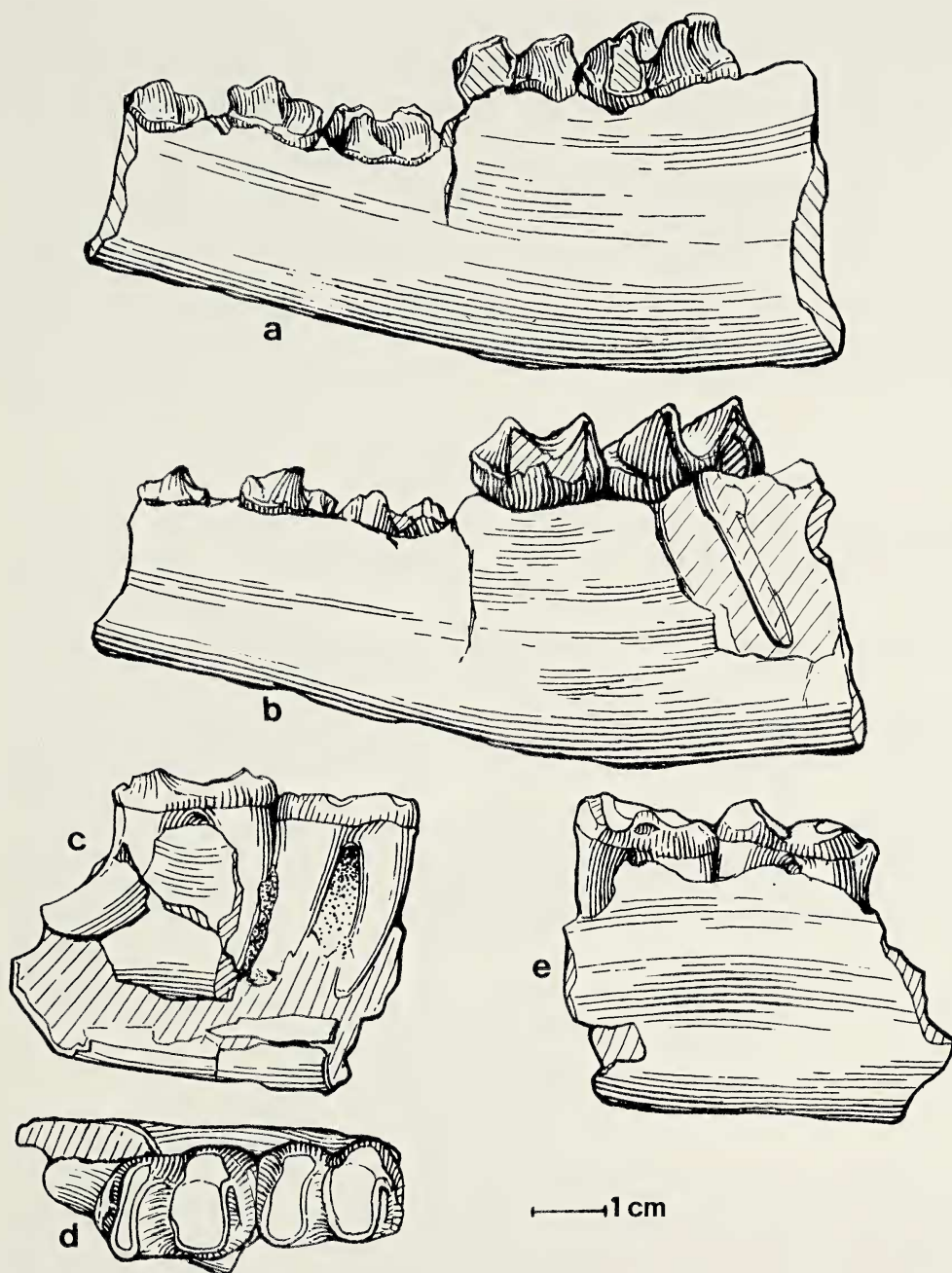


Fig. 41.—*Teleolophus primarius* new species. (a), (b) holotype, V5761, mandible with P_2 – M_2 , external and internal views; (c), (d), (e) V5762, mandible, with M_{2-3} , internal, crown, and external views.

Table 13.—Measurements (mm) of *Teleolophus primarius*.

Teeth	V5761		V5762		V5763-1		V5763-2		V5763-3		V5764		V5765-1		V5765-2	
	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W
P ₂	10.9	7.2														
P ₃	11.7	8.6	12.5	8.6												
P ₄	15.0	9.6														
M ₁	15.2	11.1					15.9?	11.6								
M ₂	17.6	12.6														
M ₃			18.2	13.4												
Minimum width of symphysis			21.2	14.7					21.3	14.5						
			20.7													
Carpals																
Length: upper-lower																
left-right																
anterior-posterior																
Phalanges																
First (V5763-7)																
Upper-lower																
Left-right																
Ant.-post.																
Second (V5763-8)																
Upper-lower																
Left-right																
Ant.-post.																
Third (V5763-9)																
Upper-lower																
Left-right																
Ant.-post.																
Fourth carpal V5763-6																
20.6 (ca.)																
22.5																
16.7																
Under second carpus																
Upper-lower																
Left-right																
Ant.-post.																
Under third carpus																
Upper-lower																
Left-right																
Ant.-post.																
Under fourth carpus																
Upper-lower																
Left-right																
Ant.-post.																

marius; 3) on P_2 of *T. primarius* the metalophid is more labial, the metalophid is shorter, the entoconid is absent, and the protoconid and metaconid are not completely separated; 4) P_3 is shorter and wider in *T. primarius* and there is an apparent notch separating the protolophid and metalophid, whereas this notch is absent in *T. medius*; a P_3 entoconid is lacking in *T. primarius* but present in *T. medius*; 5) P_4 is longer and wider in *T. primarius*, the notch between protolophid and metalophid is stronger, the paralophid is shorter and the metalophid longer; there is no entoconid, and a rib-like crest occurs on lingual wall of hypoconid; 6) the M_{1-2} paralophid is stronger in *T. primarius*; 7) the posterior root on M_3 is curved posteriorly in *T. primarius* but is straight in *T. medius*.

These differences suggest the following phylogenetic trends in the genus *Teleolophus*: 1) reduction of incisors; 2) entoconid becoming prominent; 3) positions of metalophids of P_{2-3} becoming more labial; and 4) P_2 protoconid gradually separating from metaconid.

***Teleolophus? rectus*, new species**
(Fig. 42; Table 14)

Holotype.—V5766: two broken pieces of mandible with left P_4 (anterior part broken) and M_1 , and right P_4 (posterior part broken), P_{2-3} , and M_2 only roots left (field no. 1P₅H₈).

Locality.—Ulan Bulak.

Diagnosis.— P_4 : paralophid closer to lingual edge of crown, metalophid aligned almost with the medial part of the talonid; entoconid indistinct.

Description.— P_4 : paralophid short, originates from protolophid rather than protoconid, so trigonid very short; metalophid almost medial on talonid; entoconid indistinct; cingula very weak and no internal cingulum. M_1 : paralophid relatively short; metalophid developed, not connected with protolophid.

Discussion.—The main characters of *Teleolophus rectus* are the position of the paralophid of P_4 , which is closer to the lingual edge of the crown, the metalophid located almost medially on the talonid, and presence of a weak entoconid. In tooth morphology, *T. rectus* appears intermediate between *T. primarius* and *T. medius*.

Suborder Brontotherioidea Hay, 1902

Family Brontotheriidae Marsh, 1873

Telmatherium Marsh, 1872

Telmatherium cristatum (Granger and Gregory, 1943)

Metatelmatherium cristatum Granger and Gregory, 1943.

Discussion.—Granger and Gregory (1943, pp. 355–356) discovered that “the type skull of *Telmatherium ultimum* Osborn from the Uinta (upper Eocene) of North America so closely resembles the type of our *Metatelmatherium cristatum* in all aspects that one can barely discover specific differences between them . . .” Nevertheless, they erected a new genus, *Metatelmatherium*, from the Arshanto fauna, believing that it represented “a distinct generic stage characteristic of the upper Eocene of North America and Mongolia, a stage which is much larger and has more advanced premolars than the true *Telmatherium* . . .” The age of the Arshanto beds and Irдин Manha beds is now recognized as middle Eocene as is the North American Uintan. “*Metatelmatherium*” does not warrant recognition.

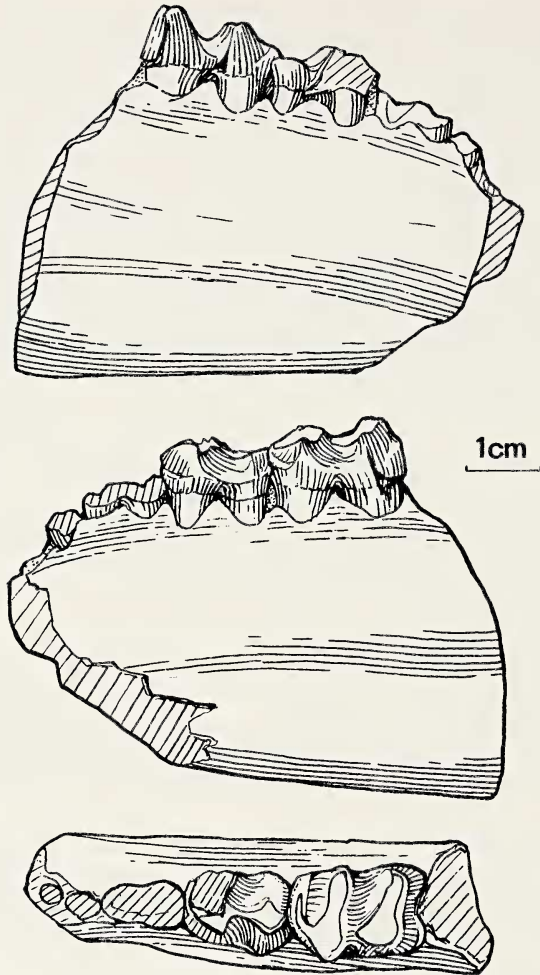


Fig. 42.—*Teleolophus? rectus* new species. Holotype, V5766 (in part), right mandible with left P_4 - M_1 , external, internal, and crown views.

Desmatotitan Granger and Gregory, 1943

Desmatotitan sp.

(Fig. 43)

Referred specimen.—V5769: left M_3 (field no. 77036-2).

Locality.—Huhe Bulak.

Discussion.—This tooth is wider and 10 mm longer than that of *Microtitan mongoliensis*, and is closer in size to that of *D. tukhumensis* (Ulan Shireh). V5769 also resembles that of *D. tukhumensis* in having relatively distinct cingula.

Measurements.—V5769, M_3 , L/W: 58/28 mm.

Protitan minor Granger and Gregory, 1943

Holotype.—AMNH 26416. A skull, lacking the distal end of the nasals.

Locality.—Camp Margetts.

Table 14.—Measurements (mm) of *Teleolophus? rectus* (V5766).

	Left		Right	
	L	W	L	W
P ₂	9.7?			
P ₃	10.3?		9.9	
P ₄	13.2	10.3	13.6	10.0
M ₁	16.1	10.8	15.0?	
Depth of mandible below P ₄ and M ₁	34.2		35.3	

Discussion.—Granger and Gregory (1943, pp. 358–359) erected this genus, which includes six species. Of them, only *Protitan minor* was collected from “probably top of Irдин Manha beds,” “Camp Margetts,” that is, from the top of what are here recognized as the Arshanto beds. Other species are probably based on materials from the Irдин Manha beds. Specific characters of *P. minor* are as follows (Granger and Gregory, 1943): “P¹ small, compressed; P² oblique, asymmetric, narrow; P³ narrow; P⁴ not nearly so wide as in *Epimanteoceras formosus*; M¹ of moderate width, M² narrow, M³ fairly narrow; P⁴ with slight tetartocone ridge but no cusp. Zygomata not wide. Basisphenoid pits conspicuous. Lower jaw not definitely known but the distance from the hypocone to the anterior rim of P² (217), which should be equal to the distance from the hypoconulid to the tip of P₂, is nearly matched in a lower jaw, AMNH 26410, from the same locality and horizon. This jaw agrees well in other measurements and dental characters with the type skull and is therefore referred to this species. It differs from the type of *D. olseni* chiefly in its smaller dimensions but tends to confirm the reference of that form to *Protitan grangeri*. AMNH 20108, a maxilla, is close to *P. minor* in general, but the M³ is much larger. The latter is in an early stage in lengthening, a process which was carried to an extreme in *Gnathotitan*.”

Microtitan Granger and Gregory, 1943

Microtitan? elongatus, new species

(Fig. 44)

Holotype.—V5767, right P³–M³ (M¹ and M² largely broken; M³ preserves only mesostyle and metacone) (field no. 77028H₂).

Locality.—Daatein Obo.

Diagnosis.—Larger than *Microtitan mongoliensis*; P³ and P⁴ wider than long (although width of P³ is close to that of P⁴), mesostyles on P³ and P⁴ well developed and forming triangular processes on the external walls of the teeth, cingula developed.

Description.—P³: protocone prominent; paracone and metacone present; parastyle fairly well developed; mesostyle high, forming a triangular process on the external wall, which connects with prominent external cingulum; metastyle also fairly distinct; the base of the tooth rounded by a cingulum which separates from external cingulum at the parastyle and the metastyle. P⁴: similar to P³, but wider and parastyle more prominent. M¹: (protocone and hypocone heavily worn) metacone well developed. M²: apparently larger than M¹, with no wear on hypocone. M³: (only ectoloph preserved) the distance between paracone and mesostyle is smaller than that between mesostyle and metacone.

Discussion.—*Microtitan? elongatus* is slightly larger than *M. mongoliensis*. P³ and P⁴ of *Microtitan? elongatus* are wider than long and rectangular in crown view whereas P³⁻⁴ are square in *M. mongoliensis*. The mesostyles on P³⁻⁴ of *M.?*

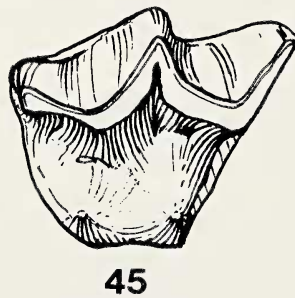
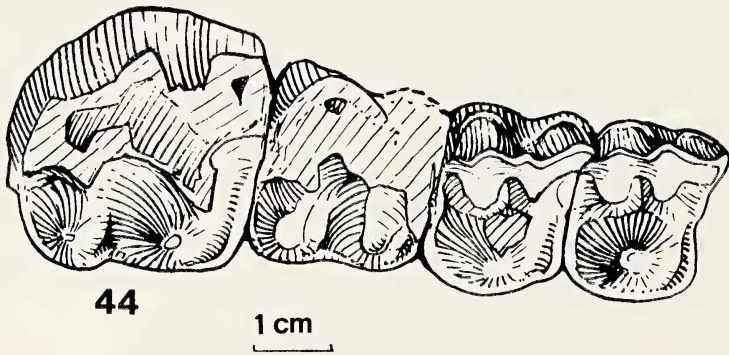
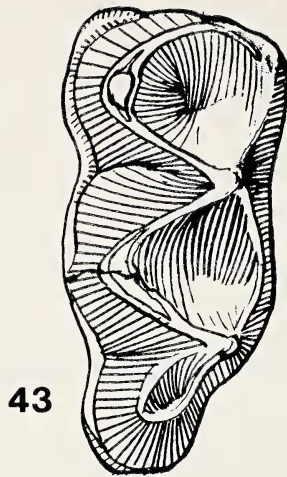


Fig. 43.—*Desmatotitan* sp. V5769, right M_3 .

Fig. 44.—*Microtitan?* *elongatus* new species. Holotype, V5767 (in part), P^3 – M^2 .

Fig. 45.—*Microtitan* sp. V5768, right M^2 .

elongatus and especially the triangular processes on the external wall are rarely seen in titanotheres and are absent in *M. mongoliensis*. On P³ and P⁴ of *Microtitan?* *elongatus* the basal cingula are more nearly continuous than in *M. mongoliensis*.

Microtitan? *elongatus* differs from *Protitan minor* (AMNH 26417) as follows: P³⁻⁴ are apparently smaller; widths of P³ and P⁴ are subequal (P⁴ is larger than P³ in *P. minor*); P³⁻⁴ protocones are more prominent; and the paracone is almost medial on the ectoloph whereas it is more anterior in *Protitan minor*.

Measurements.—L/W: P³, 19.0/23.3 mm; P⁴, 17.7/24.6 mm.

Microtitan sp.
(Fig. 45)

Referred specimen.—V5768, right M² (field no. 77027).

Locality.—Huhe Bulak.

Discussion.—This tooth was found low in the Arshanto section along with *Microtitan elongatus*.

Measurements.—V5768, M², L/W: 37/29 mm.

Suborder Rhinoceroidea Gill, 1872
Family Hyracodontidae Cope, 1879
Forstercooperia Wood, 1939
***Forstercooperia huhebulakensis*, new species**
(Fig. 46; Table 15)

Holotype.—V5770, a broken skull with P⁴–M³ (field no. 77036-2).

Referred specimen.—V5771, a broken mandible with P₃–M₃ (M₃ heavily broken) (77036-2); V5772, M₂ and M₃ (77036-2).

Locality.—Huhe Bulak.

Diagnosis.—Skull low; zygomatic arch long; upper cheek teeth similar to those of *Forstercooperia confluens*, but M³ with metacone; metalophids long and connect with protolophids. Differs from *F. totadentata* in its apparently smaller size and from *F. confluens* in having 1) zygomatic arch flatter and straighter; 2) in lateral view flatter frontal and nasal bones; 3) M² and M³ without anti-crochets. Differs from *F. sharamurunensis* in having less molarized premolars.

Description.—Skull: frontal flat and low; zygomatic arch relatively flat and straight; anterior edge of orbit anterior to M³; sagittal crest well developed, parietal fairly high; interparietal very distinct; occipital crest thin; occipital part deeply convex forward; occipital condyle large; paramastoid process may be very robust; length of bulla, 27 mm. P⁴: paraloph and metaloph form a semi-circle with wear; anterior and posterior cingula present; no internal nor external cingula. M¹: (heavily worn) paraloph fairly robust; metaloph more robust; paracone prominent forming a clear paracone rib; metacone relatively prominent, but metacone rib not present; angle between metaloph and metacone crest about 90°; anterior cingulum weak; no internal nor posterior cingula, external cingulum short, near ectoloph. M²: larger in size; paraloph robust; dental wall with posteriorly projecting process at the position of the anti-crochet; paracone prominent; metacone rib fairly strong, the angle between metaloph and metacone (crest) about 90°; paraloph and metaloph connect at the base; anterior and posterior cingula weak. M³: no anti-crochet; parastyle not prominent; paracone high; ectoloph connects with metaloph forming straight crest, but metacone very distinct; paraloph not connecting with metaloph at the base; anterior cingulum relatively strong.

Mandible: vertical edge fairly flat and straight; the angle between horizontal ramus and ascending ramus larger than 90°; foramen mentale clear. P₃: protoconid close to metaconid; protolophid long; metalophid fairly short; no cingulum. M₁: smaller than M₂; protolophid parallel to hypolophid; metalophid not connecting with protolophid; no cingulum. M₂: similar to M₁, but with extremely weak cingulum on external wall. M₃: (heavily broken) metalophid connects with protolophid.

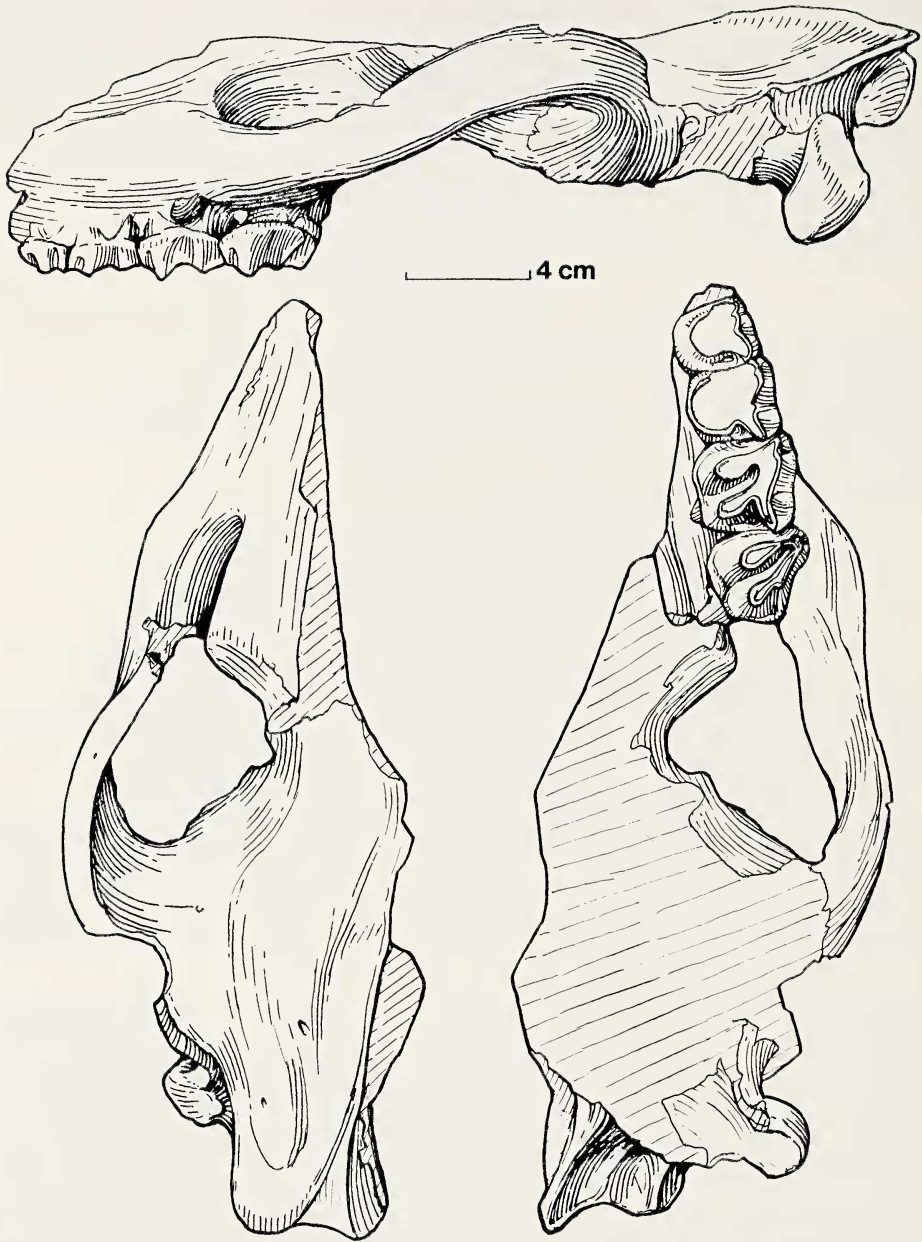


Fig. 46.—*Forstercooperia huhebulakensis* new species. Holotype, V5770, skull, lateral, dorsal, and palatal views.

Discussion.—The family Hyracodontidae has 11 genera, of which most are Eocene; *Ardynia*, *Urtinotherium*, and *Indricotherium* are Oligocene.

The shape of the upper cheek teeth agrees with *Forstercooperia*, especially P^4 and M^3 . The length of M^{1-3} of *F. huhebulakensis* is close to that of *F. confluens*

Table 15.—Measurements (mm) of *Forstercooperia huhebulakensis*.

	L	W
<i>V5770</i>		
P ⁴	20.0	23.5
M ¹	24.5	27.5
M ²	29.2	30.3
M ³	26.0	30.0
M ¹⁻³	79.7	
Length, anterior edge of orbital fossa to condyle	213.0	
Width, across zygomatic arch	190.0	
Height, from lower border of condyle to occipital crest	93.0	
<i>V5771</i>		
P ₃	13.7	10.2
P ₄	16.0	12.9
M ₁	22.2	17.0
M ₂	26.3	17.7?
M ₃		17.0?
<i>V5772</i>		
M ₂	26.8	19.1
M ₃	29.8	18.0
Depth, mandible below M ₁	50.0	

(79.7 mm and 87.1–90.5 mm, respectively). *F. huhebulakensis* differs from species of *Hyracodon* in having the paracone higher than the ectoloph whereas in the latter the paracone is weak and not separated from the ectoloph. *F. huhebulakensis* differs from species of *Triplopus* in that the M³ has a distinct metacone, and from species of *Allacerops* in being smaller.

F. huhebulakensis occurs stratigraphically lower than other species of this genus. Some phylogenetic trends within this genus (from *F. huhebulakensis* to *F. confluens* and *F. totadentata* to *F. sharamurunensis*) are: 1) increase in size; 2) nasal notch more posterior; 3) molarization of premolars. As Radinsky (1967b) suggested, *Forstercooperia* may be the ancestor of *Indricotherium*.

Forstercooperia? grandis (Peterson) 1919
(Fig. 47a)

Referred specimen.—V5773, right P⁴ (ectoloph missing).

Discussion.—The cingulum continuous on the internal side of the tooth; the paraloph is long, the protocone robust, metaloph short, and crista evident. This tooth is larger than P⁴ of *F. huhebulakensis*, and resembles that of North American *Forstercooperia? grandis* (UCMP 69722). The metaloph of the North American form is not continuous nor is it in the Inner Mongolian specimen after wear. In dimensions this tooth is close to P⁴ of *F. totadentata*, but the latter lacks a continuous cingulum and crista.

Measurements.—V5773, P⁴, L/W: 19.4/22.1 mm (ca.).

Forstercooperia sp.
(Fig. 47b, c)

Referred specimens.—V5777, left M³ (field no. 77028H₂); V5774, right M₂ (77028H₂).

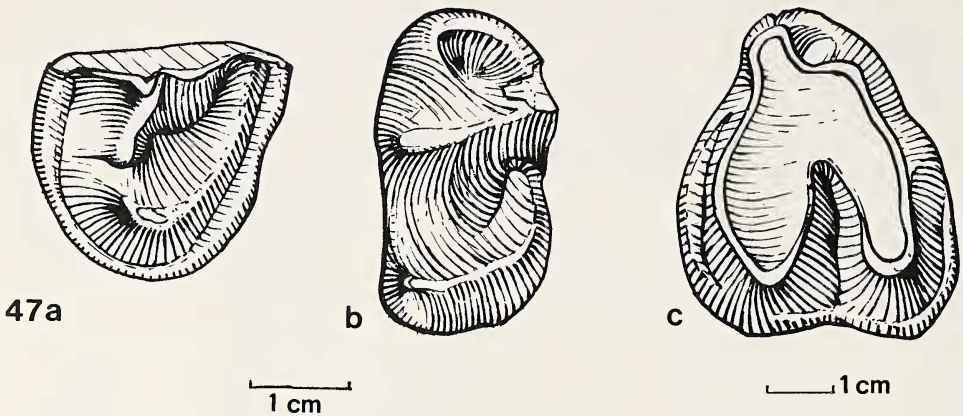


Fig. 47a-c.—*Forstercooperia?* *grandis*. V5773, right P⁴. b, c.—*Forstercooperia* sp. (b) V5774, right M₂; (c) V5777, M³.

Locality.—Daatein Obo.

Discussion.—In regard to the dental pattern, M³ (V5777) is quite similar to M³ of *Urtinotherium incisivum*, but the dimensions are too different between the two M³s. Besides this, V5777 has a small cingulum while *Urtinotherium incisivum* lacks one. The discovery of this tooth provides some clue to the phylogeny of the Hyracodontidae. The length of V5774 (M₂) is close to that of *Forstercooperia confluens* but its width is less. The width of the protolophid is larger than that of metalophid, a phenomenon rarely seen in the family Hyracodontidae.

Measurements.—L/W: M³ (V5777), 40.0/46.5 mm.

ACKNOWLEDGMENTS

I thank the following American colleagues who so graciously helped me to complete the study of the Arshanto Fauna: Drs. M. R. Dawson, L. Krishtalka, and R. K. Stucky, Carnegie Museum of Natural History; Drs. M. C. McKenna, R. H. Tedford, and M. J. Novacek, American Museum of Natural History. Special thanks go to Drs. Dawson, Krishtalka, and McKenna, for giving so much of their time and energy to discussing and correcting the English manuscript. Dr. Dawson also encouraged me to complete this study. I am very grateful to Miss Elizabeth A. Hill, Carnegie Museum of Natural History, for typing and proofreading the manuscript several times, and to her and Andy Redline for remounting the plates.

I would also like to thank the following Chinese colleagues for their help and support: Zhai Ren-jie, Wang Ban-yue, Huang Xue-shi, Ye Jie, Wang Zhe-fu, Hou Jin-feng, Yang Ming-wen, Hu Hui-ching, Shou Hua-quan, Chen De-wang, Peng Chuen, Xie Dang, and Xie Shu-hua, IVPP; and especially Dr. Ming-zhen Zhou, IVPP, my professor, for his patient guidance and help both in field work and laboratory research.

For discussions in the field I thank the following American colleagues: Drs. M. C. McKenna, W. A. Clemens, Jr. (University of California) (1981), J. A. Wilson (University of Texas), M. R. Dawson, and J. A. Schiebout (Louisiana State University) (1983).

LITERATURE CITED

- BERKEY, C. P., AND F. K. MORRIS. 1924. Basin structure in Mongolia. *Bulletin of the American Museum of Natural History*, 51(5):103-127.
- . 1927. *Geology of Mongolia*. American Museum of Natural History, 475 pp.
- CHOW, MIN-CHEN. 1957. Notes on some mammalian fossils from the Late Cenozoic of Sinkiang. *Vertebrata Palasiatica*, 1(1):33-41.

- . 1963. Tillodont materials from Eocene of Shantung and Honan. *Vertebrata PalAsiatica*, 7: 97–104.
- COPE, E. D. 1872. Description of some new Vertebrata from the Bridger group of the Eocene. *Proceedings of the American Philosophical Society*, 12:460–465.
- DAWSON, M. R., CHUAN-KUEI LI, AND TAO QI. 1984. Eocene ctenodactyloid rodents (Mammalia) of eastern and central Asia. *Special Publication Carnegie Museum of Natural History*, 9:138–150.
- DEHM, R., AND T. ZU. OETTINGEN-SPIELBERG. 1958. Palaeontologische und geologische Untersuchungen im Tertiär von Pakistan 2. Die mitteleocänen Säugetiere von Ganda Kas bei Basal in Nordwest Pakistan. *Abhandlungen Bayerische Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Klasse, new series* 91:1–54.
- DOMNING, D. P., C. E. RAY, AND M. C. MCKENNA. 1986. Two new Oligocene desmostylians and a discussion of Tethytherian systematics. *Smithsonian Contributions to Paleobiology*, 59:1–56.
- GAO, YU. 1976. Eocene vertebrate localities and horizons of Wucheng and Xichuan basins, Henan. *Vertebrata PalAsiatica*, 14(1):26–34.
- GRANGER, W., AND C. P. BERKEY. 1922. Discovery of Cretaceous and older Tertiary strata in Mongolia. *American Museum Novitates*, 42:1–7.
- GRANGER, W., AND W. K. GREGORY. 1934. An apparently new family of amblypod mammals from Mongolia. *American Museum Novitates*, 720:1–8.
- . 1943. A revision of the Mongolian titanotheres. *Bulletin of the American Museum of Natural History*, 80(10):349–389.
- HUANG, XUE-SHI, AND TAO QI. 1982. Notes on fossils of the tapir group from the Late Eocene of Lunan County, Yunnan Province. *Gu Jizhui Dongwe yu Gu Renlei*, 20(4):315–326.
- MATTHEW, W. D. 1907. The relationships of the "Sparassodonta." *Geological Magazine*, (5)4:531–535.
- MATTHEW, W. D., AND W. GRANGER. 1925a. Fauna and correlation of the Gashato Formation of Mongolia. *American Museum Novitates*, 189:1–12.
- . 1925b. New mammals from the Irдин Manha Eocene of Mongolia. *American Museum Novitates*, 198:1–10.
- . 1925c. The smaller perissodactyls of the Irдин Manha Formation, Eocene of Mongolia. *American Museum Novitates*, 199:1–9.
- . 1926. Two new perissodactyls from the Arshanto Eocene of Mongolia. *American Museum Novitates*, 208:1–5.
- MATTHEW, W. D., W. GRANGER, AND G. G. SIMPSON. 1929. Additions to the fauna of the Gashato Formation of Mongolia. *American Museum Novitates*, 376:1–12.
- MCKENNA, M. C., XIANGXU XUE, AND MING-ZHEN ZHOU. 1984. *Prosarcodon lonanensis*, a new Paleocene micropternodontid palaeoryctoid insectivore from Asia. *American Museum Novitates*, 2780:1–17.
- OSBORN, H.F. 1924. *Eudinoceras*, Upper Eocene amblypod of Mongolia. *American Museum Novitates*, 145:1–5.
- OSBORN, H. F., AND W. GRANGER. 1931. Coryphodonts of Mongolia, *Eudinoceras mongoliensis* Osborn, *E. kholobolchiensis* sp. nov. *American Museum Novitates*, 459:1–13.
- . 1932. Coryphodonts and uintatheres from the Mongolian Expedition of 1930. *American Museum Novitates*, 552:1–16.
- PILGRIM, G. E. 1940. Middle Eocene mammals from north-west India. *Proceedings of the Zoological Society of London*, 110A:127–152.
- QI, TAO, AND ZHENYA MENG. 1983. The discovery of *Hyrachyus modestus* and *Rhodopagus* sp. nov. (Mammalia, Perissodactyla) in Laiwu County, Shandong. *Vertebrata PalAsiatica*, 21(2):103–108.
- RADINSKY, L. B. 1964. Notes on Eocene and Oligocene fossil localities in Inner Mongolia. *American Museum Novitates*, 2180:1–11.
- . 1965. Early Tertiary Tapiroidea of Asia. *Bulletin of the American Museum of Natural History*, 129(2):181–263.
- . 1967a. *Hyrachyus*, *Chasmotherium*, and the early evolution of helaletid tapiroids. *American Museum Novitates*, 2313:1–11.
- . 1967b. A review of the rhinocerotoid family Hyracodontidae (Perissodactyla). *Bulletin of the American Museum of Natural History*, 136(1):1–45.
- RANGA RAO, A. 1972. New mammalian genera and species from the Kalakot Zone of Himalayan Foot Hills near Kalakot, Jamma and Kashmir State, India. *India Oil and Natural Gas Commission, Directorate of Geology, Special Paper no. 1*, 19 p.
- RESHETOV, V. Y. 1975. [Review of Early Tertiary Tapiroidea of Mongolia and USSR. The Joint

- Soviet-Mongolian Paleontological Expedition, Transactions, Vol. 2: Fossil fauna and flora of Mongolia], pp. 19–53. (In Russian.)
- ROMER, A. S. 1966. Vertebrate paleontology. University of Chicago Press (3rd edition), 468 pp.
- SAHNI, A., S. B. BHATIA, J.-L. HARTENBERGER, J.-J. JAEGER, K. KUMAR, J. SUDER, AND M. VIANEY-LIAUD. 1981. Vertebrates from the Subathu Formation and comments on the biogeography of Indian subcontinent during the early Paleogene. *Bulletin de la Societ  G ologique de France*, 23(6):689–695.
- SIMPSON, G. G. 1945. The principles of classification and a classification of mammals. *Bulletin of the American Museum of Natural History*, 85:1–350.
- STUCKY, R. K., AND L. KRISHTALKA. 1983. Revision of the Wind River faunas, early Eocene of central Wyoming. Part 4. The Tillodontia. *Annals of Carnegie Museum*, 52(17):375–391.
- SZALAY, F. S., AND S. J. GOULD. 1966. Asiatic Mesonychidae (Mammalian, Condylarthra). *Bulletin of the American Museum of Natural History*, 132(2):1–173.
- SZALAY, F. S., AND M. C. MCKENNA. 1971. Beginning of the Age of Mammals in Asia: the Late Paleocene Gashato Fauna, Mongolia. *Bulletin of the American Museum of Natural History*, 144(4):271–317.
- TONG, YONG-SHENG, AND YING-JUN TANG. 1977. A new species of *Eudinoceras*. *Vertebrata Palasiatica*, 15(2):139–142.
- WEST, R. M. 1980. Middle Eocene large mammal assemblage with Tethyan affinities, Ganda Kas region, Pakistan. *Journal of Paleontology*, 54:508–533.
- WOOD, A. E. 1962. The early Tertiary rodents of the family Paramyidae. *Transactions of the American Philosophical Society*, 52:1–261.
- WOOD, H. E. 1934. Revision of the Hyrachyidae. *Bulletin of the American Museum of Natural History*, 67:181–295.
- YE, JIE. 1983. Mammalian fauna from the Late Eocene of Ulan Shireh area, Inner Mongolia. *Vertebrata Palasiatica*, 21(2):109–118.
- YOUNG, CHUNG-CHIEN, AND MEI-NIAN BIEN. 1935. Cenozoic geology of the Wenho-Ssushui District of Central Shantung. *Bulletin of the Geological Society of China*, 14:221–246.
- ZDANSKY, O. 1930. Die Alterti ren S ugetiere Chinas nebst Stratigraphischen Bemerkungen. *Paleontologia Sinica*, 6(2):1–87.
- ZHOU, MING-ZHEN, CHUAN-KUEI LI, AND YU-PING ZHANG. 1973. Late Eocene mammalian faunas of Honan and Shansi with notes on some vertebrate fossils collected therefrom. *Vertebrata Palasiatica*, 11(2):165–181.
- ZHOU, MING-ZHEN, AND TAO QI. 1982. New materials of fossil mammals from the Middle Eocene of Xintai County, Shandong Province. *Gu Jizhui Dongwe yu Gu Renlei*, 20(4):302–314. (Chinese, English summary.)
- ZHOU, MING-ZHEN, TAO QI, AND YUNG LI. 1976. Paleocene stratigraphy and faunal characters of mammalian fossils on Nomogen Commune, Si-zi-wang-qi, Nei Mongol. *Vertebrata Palasiatica*, 14(4):228–233.

Appendix 1.—List of Irdin Manha fauna.

	Irdin Manha	Ulan Shirch	Hube Bulak (Camp Margetts)	Lushi (Henan)	Mon- golia
Order Primates					
Anaptomorphidae					
<i>Lushius qinlinensis</i>				X	
Order Insectivora					
? <i>Pantolestes</i> sp.	X				
Order Rodentia					
Paramyidae					
paramyid spp.	X				
Cocomyidae					
<i>Tsinlingomys youngi</i>				X	
Yuomyidae					
<i>Advenimus bohlini</i>		X			
cf. <i>Advenimus</i> sp.		X			
<i>Yuomys weijingensis</i>		X			
Order Lagomorpha					
Leporidae					
<i>Shamolagus grangeri</i>		X			
<i>Lushilagus lohoensis</i>				X	
Order Creodonta					
Oxyaenidae					
<i>Sarkastodon mongoliensis</i>	X	X			
Hyaenodontidae					
<i>Paracynohyaenodon morrisoni</i>	X				
<i>Propterodon irdinensis</i>	X				
<i>Hyaenodon</i> sp.				X	
Order Carnivora					
Miacidae					
<i>Miacis invictus</i>	X				
<i>M. lushiensis</i>				X	
miacid indet.		X			
Canidae					
<i>Cynodictis</i> sp.				X	
Felidae					
cf. <i>Eusmilus</i> sp.				X	
Order Acreodi					
Mesonychidae					
<i>Andrewsarchus mongoliensis</i>	X				
<i>A. henanensis</i>				X	
<i>A. gigas</i>			X	X	
<i>Hapalodectes serus</i>	X				
? <i>Hapalodectes serus</i>		X			
? <i>Harpagolestes orientalis</i>		X			
<i>Honanodon macrodontus</i>				X	
<i>Lohoodon lushiensis</i>				X	
<i>Pachyaena</i> sp.	X				
<i>Mesonyx</i> sp.	X	X			
mesonychid indet.	X	X			

Appendix 1.—Continued.

	Irdin Manha	Ulan Shireh	Huhe Bulak (Camp Margetts)	Lushi (Henan)	Mon- golia
Order Tillodontia					
Stylinodontidae					
? <i>Stylinodon</i> sp.				X	
Order Pantodonta					
Coryphodontidae					
<i>Eudinoceras mongoliensis</i>	X	X			X
<i>E. kolobolchiensis</i>					X
<i>Eudinoceras</i> sp.				X	
<i>Hpercoryphodon thomsoni</i>			X		
Pantolambdodontidae					
<i>Pantolambdodon inermis</i>		X			
<i>P. fortis</i>		X			
Order Perissodactyla					
Brontotheriidae					
<i>Telmatherium parvum</i>	X				
<i>Protitan grangeri</i>	X			X	
<i>P. robustus</i>	X				
<i>P. obliquidens</i>	X				
<i>P. bellus</i>		X			
<i>Rhinotitan grangeri</i>				X	
<i>Microtitan mongoliensis</i>	X	X			
? <i>Microtitan</i> sp.				X	
<i>Desmatotitan tukhumensis</i>		X			
<i>Epimanteoceras formosus</i>		X			
<i>Dolichorhinoides augustidens</i>		X			
<i>Acrotitan ulanshirehensis</i>		X			
brontotheriid indet.			X		
Eomoropidae					
<i>Lunania youngi</i>				X	
<i>Eomoropus</i> sp.				X	
Isectolophidae					
isectolophid indet.					X
Helaletidae					
<i>Helaletes mongoliensis</i>	X				
? <i>Colodon</i> sp.				X	
Lophialetidae					
<i>Lophialetes expeditus</i>	X	X	X		
<i>Lophialetes</i> sp.	X	X			
<i>Breviodon minutus</i>	X	X		X	X
? <i>Breviodon minutus</i>					X
cf. <i>Breviodon minutus</i>		X			
? <i>Breviodon</i> sp.		X			
<i>Parabreviodon dubius</i> (=cf. <i>Brevio-</i> <i>don acares</i> , Radinsky, 1965, prob- ably Irdin Manha beds.)	X				
<i>Simpletales sujiensis</i>	X	X			
<i>S. ulanshirehensis</i>		X			
<i>Zhongjianoletes chowi</i>		X			
<i>Zhongjianoletes</i> sp.		X			
<i>Pataecops parvus</i>					X

Appendix 1.—Continued.

	Irdin Manha	Ulan Shireh	Hube Bulak (Camp Margetts)	Lushi (Henan)	Mon- golia
Deperetellidae					
<i>Teleolophus medius</i>	X	X			X
<i>Deperetella</i> sp.				X	
Hyracodontidae					
<i>Rhodopagus pygmaeus</i>	X	X			
<i>Rhodopagus</i> sp.					X
? <i>Triplopus proficiens</i>	X	X			
<i>Triplopus</i> sp. (= <i>Caenolophus</i> or Amyndontidae)				X	
<i>Forstercooperia totadentata</i>	X				
<i>Forstercooperia</i> cf. <i>grandis</i>		X			
<i>Forstercooperia</i> spp.				X	
<i>Teilhardia pretiosa</i> ("Ulan Shireh" beds)		X			
<i>Prohyracodon</i> sp.				X	
Amyndodontidae					
<i>Lushiamynodon menchiapuensis</i>				X	
? <i>Lushiamynodon sharamurunensis</i>		X			
<i>Sianodon honanensis</i>				X	
Order Artiodactyla					
Dichobunidae					
<i>Dichobune</i> sp.				X	
Choeropotamidae					
<i>Gobiohyus orientalis</i>	X	X?		X	
<i>G. pressidens</i>	X				
<i>G. robustus</i>	X			X	
Cebochoeridae					
achaenodont indet.	X				
Anthracotheriidae					
<i>Anthracotherium</i> spp.				X	
Leptomerycidae					
cf. <i>Archaeomeryx</i> indet.	X				
Order indet.					
Didymoconidae					
<i>Mongoloryctes auctus</i>	X				
<i>Kennatherium shirehensis</i>		X			

Appendix 2.—Middle Eocene mammals in the central part of Shandong Province.

	Xintai	Mengyin	Laiwu
Order Condylarthra			
Hyopsodontidae			
? <i>Haplomylus</i> sp.		X	
Order Tillodontia			
Esthonychidae			
<i>Kuanchuanius shangtungensis</i>	X		
Order Pantodonta			
Coryphodontidae			
<i>Coryphodon flerowi</i>	X		
<i>Metacoryphodon xitaiensis</i>	X		
Order Dinocerata			
Uintatheriidae			
cf. <i>Uintatherium?</i> sp.	X		
Order Rodentia indet.	X		
Order Creodonta			
Hyaenodontidae			
<i>Thinocyon? sichowensis</i>	X		
Order Perissodactyla			
Equidae			
<i>Propalaeotherium sinense</i>		X	
<i>Propalaeotherium</i> sp.	X		
(Hyracotheriinae: two species, no names, Zdansky, 1930)		X	
Brontotheriidae			
gen. and sp. indet.	X		
Chalicotheriidae			
<i>Grangeria canina</i>	X		
Helaletidae			
<i>Hyrachyus modestus</i>			X
<i>H. modestus?</i>	X		
<i>H. metalophus</i>	X		
<i>Helaletes</i> sp.	X		
Lophialetidae			
<i>Lophialetes</i> sp.	X		
<i>Schlosseria</i> sp.	X		
<i>Breviodon? minutus</i>	X		
Deperetellidae			
<i>Teleolophus shandongensis</i>	X		
<i>Teleolophus</i> sp.	X		
Hyracodontidae			
<i>Rhodopagus laiwuensis</i>			X
<i>Rhodopagus</i> sp.	X		
Order indet.			
<i>Heptaconodon dubium</i>		X	

Appendix 3.—Middle Eocene mammals in Zaisan Basin, Kazakhstan, U.S.S.R.

	Aksyir	Tschai- bulak	Obaila	Kalmak- pay	Ulken- Ulasty
Order Rodentia					
Cocomyidae					
<i>Tamquammys tantillus</i>	X	X			X
Yuomyidae					
<i>Saykanomys chalchas</i>	X				X
<i>Petrokozlovia notas</i>	X				
Order Lagomorpha					
Leporidae					
<i>Shamolagus</i> sp.	X				
Order Condylarthra indet.		X			
Order Creodonta					
Hyaenodontidae					
cf. <i>Limnocyoninae</i>					X
deltatheriid indet.					X
Order Pantodonta					
Coryphodontidae					
<i>Eudinoceras obailensis</i>			X	X	
pantodont indet.					X
Order Perissodactyla					
Brontotheriidae					
<i>Palaeosyops</i> sp.	X				
Isectolophidae					
<i>Isectolophus bogdulensis</i>			X		
cf. <i>Isectolophus</i> sp.		X			
Helaletidae					
<i>Veragromovia desmatotheroides</i>			X		
<i>Helaletes</i> cf. <i>mongoliensis</i>			X		
<i>Helaletes</i> sp.	X				
helaletid indet.					X
Lophialetidae					
<i>Lophialetes</i> cf. <i>expeditus</i>				X	
<i>Lophialetes minor</i>				X	
<i>Lophialetes</i> n. sp.		X			
<i>Breviodon</i> sp.	X				
lophialetid indet.		X			
Deperetellidae					
<i>Teleolophus</i> cf. <i>medius</i>			X		
deperetellid indet.					X
Hyracodontidae					
<i>Rhodopagus</i> cf. <i>pygmaeus</i>		X			
<i>Triplopus</i> cf. <i>implicatus</i>			X	X	
<i>Triplopus</i> sp.		X	X	X	
cf. <i>Triplopus</i> sp.	X				
<i>Prohyracodon</i> sp.	X				
hyracodontid indet.				X	
Order Artiodactyla					
Dichobunidae					
dichobunid indet.	X				
Order uncertain					
<i>Paraphenocodus solivagus</i>	X				
<i>Aksyiria oligestus</i>	X				

Appendix 4.—Middle Eocene mammals from Pakistan and India.

	Ganda Kas	Kalakot	Chor- lakki	Kutch	Kohat
Order Insectivora indet.			X		
Order Chiroptera indet.			X		
Order Primates					
Adapidae indet.			X		
Order Condylarthra(?)					
Hyopsodontidae(?)					
<i>Dulcidon gandaensis</i>	X				
Order Acreodi					
Mesonychidae					
cf. <i>Honanodon</i>		X			
indet.	X				
Order Tillodontia					
<i>Basalina basalensis</i>	X		X		
Order Cetacea					
Protocetidae					
<i>Pakicetus inachus</i>					X
<i>Gandakasia potens</i>	X		X		
<i>Protocetus sloani</i>				X	
<i>P. horudiensis</i>				X	
<i>P. attoki</i>	X				
indet.	X				
<i>Indocetus ramani</i>				X	
<i>Ichthyolestes pinfoldi</i>	X		X		
Agorophiidae					
<i>Andrewsiphium kutchensis</i>				X	
<i>A. minor</i>				X	
Order Creodonta					
Hyaenodontidae					
<i>Paratritemnodon indicus</i>	X	X	X		
Order Carnivora					
Miacidae indet.			X		
Order Sirenia					
Protosirenidae					
<i>Protosiren fraasi</i>				X	
Order Proboscidea					
Anthracobunidae					
<i>Lammidhanian wardi</i>	X				
<i>Jozaria palustris</i> (Kohat District)					X
<i>Anthracobune pinfoldi</i>	X	X		X	
<i>A. pilgrimi</i>	X				
Order Perissodactyla					
Hyracodontidae					
<i>Prothyraodon(?) kalakotensis</i>		X			
<i>Forstercoopertia jigniensis</i>		X			
Isectolophidae					
<i>Sastrilophus dehmi</i>		X			

Appendix 4.—Continued.

	Ganda Kas	Kalakot	Chor- lakki	Kutch	Kohat
Helaeletidae					
<i>Hyrachyus asiaticus</i>		X			
<i>H. (Chasmotherium) mckennai</i>		X			
Deperetellidae					
<i>Teleolophus(?) daviesi</i>	X				
Lophialetidae					
<i>Schlosseria radinskyi</i>		X			
<i>Kalakotia simplicidentata</i>	X				
<i>Aulaxolophus quadrangularis</i>		X			
Brontotheriidae					
<i>Eotitanops dayi</i>	X				
<i>Pakotitanops latidentatus</i>	X				
Order Artiodactyla					
Helohyidae					
<i>Khirtharia dayi</i>	X	X	X		
<i>Gobiohyus orientalis</i>	X				
Dichobunidae					
<i>Kunmunella rajauriensis</i>		X			
<i>Chorlakkia hassani</i>			X		
Choeropotamidae					
<i>Indohyus(?) kalakotensis</i>		X			
<i>Indohyus indirae</i>		X	X		
Raoellidae					
<i>Raoella dograi</i>		X			
<i>Anthracokeryx</i> sp.	X				
<i>Haqueina haquei</i>	X				
Order Rodentia					
Cocomyidae					
<i>Tamquammys</i> sp.				X	
Chapattimyidae					
<i>Saykanomys ijlsti</i>	X				
<i>S. chalchae</i>	X	X			
<i>S. vandermueleni</i>	X				
<i>S. sondaari</i>	X				
<i>S. lavocati</i>	X				
<i>Chapattimys ibrahimshahi</i>	X				
<i>C. wilsoni</i>	X				
<i>Petrokoslovia</i> sp.				X	
<i>Metkamys blacki</i>		X			